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*THE TRAINING AND WORK OF A GEOLOGIST.**

GEOLOGY is a dynamic science, subject to the laws of energy. Geology treats of a world alive, instead of, as commonly supposed, a world finished and dead. The atmosphere, or sphere of air, is ever unquiet; the hydrosphere, or sphere of water, is less active, but still very mobile; the lithosphere, or sphere of rock, has everywhere continuous although slow motions. The motions of the atmosphere, the hydrosphere, and the lithosphere alike include body motions by which the positions of large masses of material are changed, and interior motions, through which the mineral particles are constantly rearranged with reference one to another, and indeed are constantly remade. Furthermore, the molecules and even the atoms which compose the atmosphere, hydrosphere and lithosphere have motions of marvelous intricacy and speed. These motions of the atmosphere, the hydrosphere and the lithosphere, are all superimposed upon the astronomical motions—the wobbling revolution of the earth about its axis, the revolution of the earth-moon couple about their common center of gravity, the movement of this couple about the sun at the rate of 68,000 miles per hour, the

* Vice-Presidential address, Section E, Geology and Geography, American Association for the Advancement of Science, Pittsburgh Meeting, 1902.

movement of the solar system among other systems. If it were possible for one to fix in space coordinates by which to measure these various motions, the movement of an air particle, of a water drop, of a mineral grain, would be seen to be extraordinarily complex.

It is clear that there is every reason to believe that no atom or molecule in the world ever occupies the same absolute position in space at any two successive moments. Indeed, it must have been an extraordinary accident, if it ever has occurred, that a single particle has occupied in all the history of the universe exactly the same position that it has occupied at any previous time. No such thing as rest for any particle of matter anywhere in the earth or in the universe is known; but, upon the contrary, everywhere all particles are moving in various ways with amazing speed.

No science is independent of other sciences, but geology is peculiar in that it is based upon so many other sciences. Astronomy is built upon mathematics and physics. Chemistry and physics to a considerable degree are built upon each other. Physics also requires mathematics. Biology demands a limited knowledge of physics and chemistry. However, it cannot be said that a knowledge of the basal principles of more than one, or at the most two, other sciences is an absolute prerequisite for a successful pursuit of astronomy, chemistry, physics or biology. This is not true of geology. In order to go far in general geology one must have a fair knowledge of physics, chemistry, mineralogy and biology. These may be called the basal sciences of geology. In certain lines of geology the additional sciences, mathematics, astronomy and metallurgy, are very desirable.

Geology treats of the world. In order to have more than a superficial knowledge of geology, it is necessary to know about the elements which compose the world; how force acts upon these elements; what aggregates are formed by the elements and forces, and how life has modified the construction of the world. Chemistry teaches of matter; how it is made up, both in life and in death. Without an understanding of its principles we cannot have an insight into the constitution of the earth or of any part of it. Physics teaches of the manner in which the many forms of that strange something we call force acts upon matter. Without a knowledge of its principles we can never understand the transformation through which the world has gone. The elements which compose the earth under the laws of physics and chemistry aggregate into those almost lifelike bodies which we call minerals. The minerals are commingled in various ways in the rocks. Without a knowledge of mineralogy no one can have even a superficial understanding of the constitution of rock masses. Biology teaches of the substances alive which clothe the outer part of the earth. Life is one of the most fundamental of the factors controlling the geological transformations in the surficial belt of weathering; it has acted as the greatest precipitating agent in the sea. Life, has had therefore, a profound and far-reaching effect in determining the nature of the sedimentary formations.

The sciences of chemistry, physics and biology have been built up by using minute parts of the materials of the earth. If geology, or a science of the earth, is to be constructed, it must apply to the earth as a whole the principles which have so enlightened us as to the nature and relations of the fractions of the earth which we observe and handle in our laboratories of physics and chemistry and biology.

It thus appears that geology is a composite science; and it might in a certain sense be called an applied science. Indeed

I have often defined geology as the application of the principles of astronomy and physics and chemistry and mineralogy and biology to the earth.

Certainly the earth is the single enormous complex aggregate of matter directly within the reach of man. This highly composite earth is the joint result of the work of astronomical, physical, chemical and biological forces; working on an incomparably vaster scale than can ever be imitated in our laboratories. A study of these mighty results has already advanced at many points astronomy, physics, chemistry and biology, and future studies made with direct reference to the causes which have produced the earth are sure to lead to even greater advances in these studies.

If geology is to become a genetic science, or, more simply, is to become a science under the laws of energy, geology in large measure must become a quantitative science. In the past it has been too frequently true that because a single force or agent working in a certain direction is a real cause of a phenomenon, the conclusion is drawn that it is a sufficient cause. Only occasionally has the question been asked, 'Is this cause only a real cause, but is it an adequate cause?' Very often differences of opinion have arisen between geologists, one holding that this cause is the one which explains the phenomenon; another holding that that is the explanation, and each insisting that the other is wrong. In such cases very rarely is the question asked whether the explanations offered are *contradictory* or *complementary*. In many cases the explanation is not to be found in one cause, but in several or many, and thus frequently the conclusions which have been interpreted to be contradictory are really supplementary. To illustrate: But few writers have assigned more than a single cause for crustal shortening. One has held that secular cooling is *the* cause; another has given a different one, and has held that secular cooling is of little consequence. But it is certain that secular cooling, vulcanism, change of oblateness of the earth, change of pressure within the earth, changes of form of the material of the earth, and various other causes, are not exclusive of one another, but are all supplementary. The ability to perceive the supplementary nature of various explanations offered for a phenomenon is one of the most marked, perhaps the most marked, characteristics of the superior man. The new geology must not only ascertain all of the real causes for crustal shortening, and other phenomena, but in order satisfactorily to solve the problems it must determine the quantitative importance of each. Geology within the next few years is certain to largely pass to a quantitative basis.

If I have correctly stated the relations of geology to the other sciences, it follows as a corollary that those only can greatly advance the principles of geology who have a working knowledge of two or more of the sciences upon which it is based.

By a working knowledge of a science I mean such a knowledge of its principles as makes them living truths. One must not only be able to comprehend the principles, but he must see them in relation to one another; must be able to apply them. It is not sufficient for a carpenter to be able to explain how the hammer and saw and plane and chisel work; he must be able to use them. He must be able to hit the nail on the head; to cut straight; to plane smooth; to chisel true; and do all upon the same piece of timber so as to adapt it to a definite purpose in a building. Just so the geologist must be able to apply as tools the various principles of physics and chemistry and biology and mineralogy to the piece of geology upon which he is engaged; and thus shape his piece to its place in the great structure of geological

science. This is what is meant by a working knowledge of the sciences basal to geology.

It is not supposed that any one man has a comprehensive knowledge of all the basal sciences, or even a working knowledge of their principles; but such knowledge he must have of two or more of them if he hopes to advance the principles of geology. He will be able to handle those branches of his subject with which he deals in proportion as he has a working knowledge of the basal sciences upon which his special branch is based, and will probably correlate this branch with the other branches of the great subject of geology in proportion as his working knowledge of the basal sciences is extensive.

For instance, to advance geological paleontology one must have a working knowledge of the principles of biology and of stratigraphy. To advance any of the lines of physical geology, one must have a working knowledge of the principles of physics, and especially of elementary mechanics. To advance physiography one must have a working knowledge of physics and chemistry. To advance knowledge of the early history of the earth, one must have not only a working knowledge of physics and chemistry, but of astronomy. To advance petrology, one must have a working knowledge of physics, chemistry and mineralogy. To advance the theory of ore deposition or metamorphism, one must know not only the principles of physical geology, with all that implies, but he must have a working knowledge of chemistry, physics, mineralogy and petrology. It is unnecessary to add that a geologist must be able to read some of the modern languages, and be able to express himself clearly and logically in one language.

Considering the breadth and thoroughness of the necessary preliminary training for the successful pursuit of geology, one might anticipate that geology would suffer but little from pseudo-scientists. But this anticipation is based upon the idea that no one attempts geological work, and especially to write geological papers, until he is prepared to do so. All sciences have their cranks. Many a little town has its philosopher who believes that all of the principles of astronomy, of physics, of chemistry, which have been discovered by the great men of the past are absolutely erroneous, and who makes a new start upon the construction of the world, building out of his brain strange vagaries which have no relation to the facts of the universe. While there are temptations to pseudo-scientific work in all sciences, the temptation is nowhere so great as in geology. The planets, sun and stars are far off; the elements are elusive; to do anything with force one must have at least seen the inside of a physical laboratory; the manner of the transformations of living forms is not obvious, or even apparently so, and therefore few write about the constitution of plants and animals who have not closely studied them. But one is born upon the earth; he lives upon the earth; he sees the surrounding hills and valleys. The dullest sees something of the transformations going on. Many naturally become interested in the phenomena of the earth, and without preparation think that they are able to make important contributions to the subject of geology. Thus not only in every city, but in many villages, is a geologist of local repute who has ready explanations for the order of the world.

Geology starts as an easy observational study, and gradually becomes more and more complex until it taxes the master mind to the utmost. This easy start leads to the multitude of local geologists, but geology suffers comparatively little from them. The real injury which the science receives is from some of those who call

themselves professional geologists, are teachers of geology in academies and colleges, or are even members of the staff of state or government surveys. These men have gone further than the local geologist; but perhaps they have been led into the subject for somewhat the same reason, by its easy start as an observational science. A man may begin his career as a geologist by making a few observations here and there and giving a guess as to their meaning. With this beginning he becomes more and more interested, until finally he decides to make geology his profession.

In some cases following this decision the necessity is seen for obtaining a working knowledge of the basal sciences. But too often men who have entered upon geological work have received no adequate training in chemistry, in physics, in biology; and therefore at the outset wholly lack the tools to successfully interpret the phenomena which they observe. But such inadequately trained men feel that a satisfactory explanation of any phenomenon must involve a statement of the underlying chemical or physical or biological principles. In such cases it is safe to say that the explanations given are extremely partial, including only a modicum of truth, and more often than not are absolutely fallacious. Indeed, no other result can be expected from one who lacks a working knowledge of the principles of physics, chemistry and biology. Occasionally there is a clear-sighted, capable man, lacking in adequate training, who does important geological work simply because he knows his limitations, and there stops. But this is very exceptional indeed; and the physical explanations offered by many for various geological phenomena are no less than grotesque.

It has been made plain that a working knowledge of the sciences basal to geology is necessary in order to advance its principles. But I go even further, and hold that such basal knowledge is absolutely necessary in order to do even the best *descriptive* work. Suppose a man to be standing before some complex geological phenomenon. The whole intricate interlocking story is engraved upon the retina of his eye with more than photographic accuracy. The image on the retina is absolutely the same in the eye of this experienced geologist and that of a child. Yet if the child be asked to state what he sees, his statements will be of the most general kind and may be largely erroneous. The experienced geologist with a knowledge of the principles of physics and chemistry and biology interprets the phenomena imaged in terms of these subjects. The engraving on his retina is the same as that of the child, but his brain perceives the special parts of the picture of interest to him in their true proportions. He understands what is important, what is unimportant; he must select and record the things which are important. If he attempted to record all that is imaged in his eye, a notebook would be filled with the phenomena to be described at a single exposure; and yet half the story would not be told. Good descriptive work is discriminative. Good descriptive work picks out certain of the facts as of great value; others of subordinate value; and others of no value for the purposes under consideration. How then can this discrimination be made? How can the facts be selected which are of service? Only by an insight into the causes which may have produced the phenomena. Without this insight to some extent at least a description is absolutely valueless. So far as the geologist has such insight, his description is valuable.

It is frequently urged in opposition to the above that, 'If a person has theories in reference to the phenomena which he observes his descriptions will be erroneous;

he will be biased by his theories.' Unfortunately in many cases this is so; but just so far as it is true, the man fails of the qualities which make a successful geologist. One's theories undoubtedly control in large measure the selection of the phenomena which are to be noted, and the wisdom of the selection is a certain criterion of the grade of the geologist. But whatever the facts selected for record, the statement of them should be absolutely unbiased by the theories. Invariably, good practice requires that the statement of facts and the explanation of these facts shall be sharply separated. Doubtless each geologist who is listening has at different times had different ideas about the same locality, or while away from a locality a new idea has come as to the meaning of the phenomena there observed. Upon returning to the old locality with the new idea, additional observations of value have been made, but all the statements of facts at the previous visits should be found to be absolutely true. In so far as they are untrue, the geologist fails of accuracy, the first fundamental of observation. If the previous observations are found to be largely erroneous, the man who made them has small chance to become a good geologist. The difference between *bad* observation and *good* observation is that the former is *erroneous;* the latter is *incomplete*. Unfortunately in many cases not only are the observations recorded by many men absolutely false, but they are so intertwined with the theories of the author that one is unable to discriminate between what is intended to be fact and what is advanced as opinion. It is needless to say that the case of such a man is hopeless; that there is no possibility that he shall ever become a geologist. I conclude, therefore, that in order to have a standing in the future, even as a descriptive geologist, one must interpret the phenomena which he observes in the terms of the principles of astronomy, physics, chemistry, mineralogy, and biology.

If my statement thus far be true, the outline of the training of a man hoping to become a professional geologist is clear. Such a man should be sent to thorough and long courses in each of the subjects of astronomy, physics, chemistry, mineralogy and biology. This means that a large part of the training of a geologist is the study of the sciences upon which geology is founded. If a man who hopes to be a geologist is wholly lacking in a knowledge of any of the basal sciences, this defect he can probably never make good. Even if he so desires, the time cannot be found. Moreover, chemistry, physics, mineralogy and biology are laboratory sciences and can be satisfactorily handled only in the laboratory. If the fundamental work in the basal subjects has been done in the college or university, one may keep abreast of their progress during later years; but in order to do this, the basal principles must have become living truths to him while a student. If a personal illustration be allowable, during the past five years, in order to handle the problems of geology before me, I have spent more time in trying to remedy my defective knowledge of physics and chemistry and in comprehending advances in these sciences since I was a college student than I have spent upon current papers in geology; and with, I believe, much more profit to my work. If one has a working knowledge of the basal sciences and lacks training in some branch of geology, this defect he may remedy; for he has the foundation upon which to build. But if he lacks knowledge of the primary principles of the basal sciences he is likely to be a cripple for life, although this is not invariably the case. There are conspicuous instances where lack of early training in the basal sciences has been largely remedied by unusual ability and industry, but this has been most diffi-

cult. We should see to it that the young men trained in our colleges and universities, upon whom we place the degree of Doctor in Geology, are not crippled by the necessity of making good in later life defective basal training. Any university which gives a man the degree of Doctor in Geology with a defective knowledge of the basal sciences is wronging the man upon whom the degree is conferred; for this man has a right to expect that his courses shall have been so shaped as to have given him the tools to handle the problems which will arise in his chosen profession.

It is not necessary that all of the basal work shall be done before a man begins his life work, but at least a large part of this work should have been done before a man is given the certificate that he can do the work of a professional geologist. But in any case studies in the basal sciences should not cease when the professional degree is granted. Continued studies not only in the basal subjects but in cognate branches and even those far removed from science should continue through life. The geologist finds that however broad and deep his studies are in basal and cognate subjects, he is continually limited by lack of adequate knowledge of them.

In recent years it has been a mooted question in colleges and universities as to when specialization should begin, rather implying that when specialization begins broadening studies should cease. And, indeed, it is upon this hypothesis that most of the discussion upon this subject has been carried on. Some have held that specialization should not begin until late in the college course, or even rather late in a postgraduate course. Others have held that one should early direct his studies to special subjects which he expects to pursue, and give comparatively little time to other subjects. The argument for this latter course is that competition is now keen; and if a man keeps in the race he must begin to specialize early. It appears to me that both of these answers are inadequate. My answer to the question is that specialization should begin early, but that broadening studies should *not* be discontinued. This rule should obtain not only through the undergraduate course, but in the postgraduate work and during professional life. The specialized work will be better done because of the broad grasp given by the other subjects. The broadening studies will be better interpreted because of the deep insight and knowledge of a certain narrow field. Thus each will help the other. No man may hope for the highest success who does not continue special studies and broadening studies to the end of his career.

But is it held that a geologist lacking an adequate working knowledge of basal studies cannot perform useful service? No, the domain of geology is so great, the portion of earth not geologically mapped and the structure worked out is so vast, the ore and other valuable deposits which have received no study are so numerous, that there is an immense field for the application of well-established principles. In geology, as in engineering and other applied sciences, there is an opportunity for many honest, faithful men to perform useful service to the world even if their early training and capacity are not all that could be desired. But even the application of old principles to new areas will be well done in proportion as the geologist has training in the basal sciences; and to the man who combines with such training talent must necessarily be left the advancement of the philosophy of geology. The philosophy of geology, the inner meaning of phenomena, was the paramount consideration to Hutton and Lyell and Darwin. To them facts were useful mainly that they might see common factors, the great principles which underlie them,

or, in other words, generalization. To correctly generalize in geology involves the capacity to hold a vast number of facts in the mind at the same time; to see them in their length and breadth and thickness; to see them at the same time as large masses and as composed of parts, even to the constituent mineral particles and the elements; to see the principles of physics and chemistry and mineralogy and biology interlacing through them. Only by holding a multitude of facts and principles in one's mind at the same time can they be reduced to order under general laws.

Failure thus to hold in one's mind a large number of facts and principles leads to lack of consistency. Often in a single book or a single chapter, on the same page, or even in the same paragraph or sentence, are contained ideas which are exclusive of one another. They are not seen by the writer to be exclusive of one another because he is so lacking in a command of the principles of the basal sciences that he is not aware of the antagonism. Major Powell once said to me, 'The stage of the development of the human mind is measured by its capacity to eliminate the incongruous.' If this hard criterion were rigidly applied, it would follow that many of our professions have not passed the youthful stage. The man who can insert in the same treatise, chapter or page incongruous ideas saves an immense amount of cerebral tissue for himself. Such a man can write on through chapters and books, and not find it necessary to go back, adjust and interrelate the various parts. There is no action and reaction between the multitude of ideas. The writer has the easy task of holding in his mind at any one time but a few data. He is in delightful and happy unconsciousness of the fact that many of his statements destroy one another. But the man who sees the phenomena and principles of geology in all their complex relations, and tries to express the parts of them he is considering in proportion to one another, and to place his fragment of the science of geology in proper relations to other departments of geology and other natural sciences, has a task before him requiring great mental effort. He must see and understand in three dimensions. At every point he must see the lines of cause and effect radiate and converge upon the phenomena he is considering from many other phenomena and principles. Of course all fail to do this completely in reference to any complex problem. But in so far as success would be attained, the effort must be made. In proportion as one can hold many facts and principles and see their interrelations, he will be able to advance the philosophy of geology. This is the work which burns the brain.

And his results he must express in language, the chief means of communicating ideas and relations. Yet language is linear. By figures, models, maps and illustrations, wisely used, one may to an important degree supply the defects of linear language. Yet language and illustration, even where used to the best advantage, but poorly convey one's ideas. Most conscientious writers require as much or more time to put a complex subject into words and illustrations ready for publication as they do in working out the results.

But upon the other side, and in favor of expression in language, it should be remembered that there is action and reaction between one's ideas and the attempt to express them in words and illustrations. The necessity for expression in language is often a wonderful clarifier of ideas. The ideas are improved by the attempt at expression, and the expression is continually improved as the ideas are enlarged.

That the difficulty as to expression does not apply to geology alone is well illustrated by the vast amount of labor Charles Darwin

spent in putting into the linear form of language the most revolutionary work of the time, 'The Origin of Species.' It seemed as if the intricately interrelated facts of life were of so complex a nature that language could not handle the problem. But the genius of Darwin was such that he not only conceived the idea of natural selection and proved its truth to his own mind, but he so marshaled his facts and principles in linear form in one volume that men were forced to believe. Many of the ideas contained in single sentences or paragraphs of the 'Origin of Species' have been expanded into papers, volumes or treatises by others; and thus made easier to comprehend. The 'Origin of Species' has often been said to be a difficult book to read. So it is, because its ideas are more complex than language can easily convey. Darwin unquestionably saw deeper than he was able to express; and it was the struggle to state what he knew which made the writing of the 'Origin' such an onerous task. But geology as a whole is only less complex than life; and many of us in the smaller matters with which we are attempting to deal have felt the impossibility of conveying more than imperfectly the ideas and relations which are in our minds.

In thinking of the marvelous complexity of the phenomena of geology, and seeking for an analogy which might in some measure express this complexity, it seemed to me that the inhabitants of the globe and their intricate relations furnish an approximate illustration. From each individual or family or hamlet or city or metropolis, there go out on foot, by wheel, by wagon, by railway, by vessel, various products, some of them to the remoter parts of the earth. From each center, by letter, telegram, telephone, communications diverge; if the center be a large one, by thousands of lines. To each center, materials and thoughts in a like manner converge. In a similar way one class of geological phenomena is related to nearly all other classes. They are related as to their material parts, as to the forces and agents acting, and as to principle concerned in their production. For instance, an economic geologist will appreciate that the development of an ore deposit depends upon the nature of adjacent rocks, upon earth movements, upon the resultant deformation, upon fractures, upon vulcanism, upon erosion by water and ice and wind, upon the circulation of underground water. One who hopes to gain even an approximately adequate idea of the genesis of an ore deposit, and an insight as to what is probably beyond the point where the deposit is 'shown up,' must be able to handle the intricate principles of geology. In so far as a geological or mining engineer is a master of these, he rises in his profession; in so far as his knowledge of facts and principles is meager, an ore deposit seems a lawless thing which can be only dealt with on the relatively simple principle of the doctrine of chances. If an ore body happens to be found at any place, follow it. If for some unknown reason it is lost or depreciates in value, prod the ground in all directions, up and down, to the right and left, in the blind hope that chance may find more ore. In many cases nine tenths of this expensive chance work is done in a manner that a fair knowledge of the occurrences, relations and principles of ore deposits would have shown in advance to be wasted.

If the statement thus far be founded on truth, the training of a geologist is a valuable one from an intellectual point of view. It is the fashion for professors in all departments of learning each to hold that a knowledge of his subject is necessary for a liberal education. I have heard each of half a dozen professors, including the classics, history, economics, English, in a single evening each prove to his own satisfac-

tion that a man could not be a good citizen or liberally educated if a knowledge of his special subject were neglected. And at the present time some universities still hold similar views in reference to certain subjects. The claim that this or that subject is essential to a liberal education shows a lack of breadth and lack of capacity to see things in their proper relations. No one language or science is essential to a liberal education. But while this is true, it does not follow that this or that subject may not be essential for a particular career; and in geology capacity to use language for the expression of ideas is absolutely essential. Far be it from my purpose to speak in a derogatory way or to underestimate the value of any line of knowledge. At the present day a man who is trained only in science or only in the humanities has but one hand; that hand may be strong, but the man can never control the affair before him with the power, with the nicety, with which does the man with two hands, one of which is the rich treasures of science, and the other the no less rich and important treasures of the humanities, each doing its part in harmony with the corresponding fullness of results. With a fundamental knowledge of both, the scholar of the future may choose as his chief occupation the clear, cold work of science or that of the humanities, which will always have more numerous followers, because of their direct personal interest.

As I have already intimated, I hold that for the best liberal education one must pursue broadening studies from the first to the last, and also that one must early begin to specialize. If this be true, geology may be said to be a very desirable part of a liberal education; for it is built upon the whole realm of pure science; *i. e.*, the knowledge, which applies not only to the earth and all it holds, including man, but to the universe as well. Because of the breadth of training combined with specialization required of a geologist, it might be shown that geology is one of the most useful studies in giving a person a sense of proportion, ideas as to relative values, of perspective, qualities of the first order in this world. It might be held that the intellectual training of the geologist is of a kind which helps him in dealing with men and things; and, therefore, for handling the world's work. But time does not suffice to develop this part of the subject.

I shall now suppose that a geologist is adequately trained, that he has some power in generalization, and consider what should be his method of work. It is assumed that the young geologist spends a part of each year in the field. This field work should include areal mapping with structural and genetic interpretations. The wider a young geologist has traveled, the more numerous the excursions in which he has taken part, the better will be his equipment. But no general work such as this can supply the place of systematic mapping. And the more exact the mapping is, the better the training. Very frequently the educational value of the mapping in detail of a small area is underestimated. Indeed, I hold that nothing else can take its place. Moreover, the only sure way to test a geologist is to require him to delineate upon a map and in structural sections the detailed phenomena of the field. For my part I have more confidence in the future of a young geologist who has mapped in detail twenty-five square miles, and has got out of the area much that is in it, than that of another who has done no detail work but has run over and written about thousands of square miles. Rarely can the general conclusions of a man who has not done systematic mapping be relied upon. In America there have been conspicuous cases of men calling themselves geologists who have never carefully mapped a square mile. Yet some of these by the un-

discriminating have been regarded as leading geologists. And in one or two cases these men have gained a wide hearing. But the systems which they built up had little or no relation to the world; and they disappeared with the death of their authors. But a geologist must not only do systematic field work at the outset; he must continue to do such work through the years to a ripened age. Not infrequently a geologist, who in early life has done systematic field work, drops this work and continues writing geological philosophy; but this is a precarious course, which sooner or later makes of him what one of our members calls a 'closet geologist.' It is only by never-ending action and reaction between the complex phenomena of geology in the field and reflection as to the meaning of the phenomena that sure results can be obtained.

While one should spend a part of each year in the field, I suspect that many more discoveries of geological principles are made in the office or in the laboratory than in the field. The cow collects the grass in the meadow, and afterwards lies down to chew the cud and digest the food. So the geologist in the field, in the midst of innumerable facts, collects all he can. His notes are a record of his daily collections; and if a successful geologist, of his daily imperfect inferences and deductions. But during the eight or nine months of office and laboratory work he has full opportunity for reflection. He is then likely to see more of the common factors of the facts collected; is more likely to see deeper into the underlying principles which explain them.

This is still more true of the facts collected in the current and during the previous years. Indeed, in the field the observations of the current year are often too prominent on account of their recency, and it is only after some months have elapsed that they take their true proportion in connection with observations of previous years. The use of the material collected not in one year only, but through many years, is *necessarily* done in the office or in the laboratory, and it is only from such large masses of material that broad generalizations can be made.

But the inductions and deductions made in the office and the laboratory during the winter should be tested in the field in the following year in the light of the new ideas. The new ideas should not by a fraction modify the correctness of the observations of the previous years; they should be found as accurate as when made. But observations are always incomplete, and with a new idea one invariably adds valuable observations which were not noted before the idea was available.

I once wrote to a number of the geologists of this and other countries, asking the directions and dips of the dominant cleavages and joints for the various districts and regions of the world with which they were familiar. From only a single geologist did I obtain data of value. Some geologists wrote that they had not time to observe such subordinate phenomena! These men had evidently not learned the principle that the small but numerous agent or force or structure may have as great or greater importance than more conspicuous but less common ones. Darwin should have taught every scientist the principle of the quantitative importance of the small factor when he showed how great is the work of the apparently insignificant earthworm. It seems to me that joints are one of the important phenomena of geology; and this is true whether the point of view be deformation alone, physiography, metamorphism, circulation of groundwater, or the genesis of ores.

While the work of each geologist should be based upon thorough field and office work, and thus have an inductive basis, one should not there stop, but should by deduction ever be looking forward. No one ever

held more firmly to fact as a basis for induction than Darwin; but also, no man has more successfully projected by deduction beyond his facts than Darwin. This in biology was a task of extraordinary difficulty. In geology one who has a firm grasp of the principles of physics and chemistry may be more daring. Their principles, if not more definite than the laws of biology, are at least better known and more simple. Therefore, one, after having observed the facts in a district and grasped the principles which explain them, may deduce what are likely to be the facts in the field and their relations in advance of observation. Or more concretely, after one gets the correct idea as to the meaning of the phenomena for a certain district, he often can tell in advance of observation what he will see; or can find what I call 'geology made to order.'

There is no better or more severe test of a theory than one's capacity to find geology made to order. If observation of the area where the facts are expected to be found in a certain way shows that nature does not obey the order, this is certain evidence that one or more factors in the problem have been omitted and that the theory is inadequate. In so far as the theory is adequate, the geology will be found as anticipated. The reason for this is the very great complexity and delicate adjustment of the phenomena of nature. To illustrate, if the many parts of some complex machine, such as a Hoe press, or a chronometer, were scattered far and wide, and then one should gather some of these parts, and try to fit them, he might find that a certain set fit perfectly. If this were so, he would know to a certainty that these parts are in the correct positions and relations, even if he did not know the relations of these parts to other parts or the purpose of the whole; for so complex and exact is the adjustment that there is but one way to put the parts together. Another set of parts might be found and these made to fit. But doubtless certain parts would not be found. These would be missing links necessary to make a perfect machine. In this situation, if the man had a genius for mechanical construction, and an insight into principles, he might be able to understand the purpose of the whole, and finally to supply the parts which render the whole a useful machine. This he would be able to do just in proportion as he had mechanical insight.

So the geologist fits together his numerous diverse facts. If he finds a solution of his problem which gives accordance to all the numerous facts observed, he may be sure he is on the right track, even if he is incapable of seeing the full truth, for so delicate is the adjustment of facts that where they are numerous there is usually only one way to put them together. Just in proportion as the man has a working knowledge of the principles of physics and chemistry and biology, and the other cognate sciences will he be able to eliminate erroneous explanations, combine the facts into groups under true theories, and correctly infer how the different groups are to be adjusted, how the various facts which seem at first to have no definite relations are related. Or, to put it in another way, in proportion as he knows the rules of the game will he be able to correctly interpret the meaning of phenomena and from them to project into the unknown. The importance of understanding the rules of the game is not often appreciated. To the person who is ignorant of the principles of the various sciences all things are possible. So many wonderful things have happened within the past half century that he thinks it possible for anything to happen. He has no principles by which he can determine whether or not a statement is probably true. Hence all sorts of grotesque notions flourish. Indeed, the very fact that so many wonderful

things have been accomplished makes many more ready to regard as possible almost any absurdity announced by some so-called 'professor.'

Probably at no time in the history of the world has the public shown such ready credulity. Indeed, it seems as if the more grotesque and preposterous an idea the more likely it is to receive attention. And this credulity is not confined to those who are altogether ignorant of science. A man may be a very narrow expert in one direction of science and be wholly ignorant of the rules of the game in reference to another science. For instance, when an eminent biologist says 'bell-ringing, the playing on musical instruments, stone-throwing and various movements of solid bodies, all without human contact or any discoverable physical cause—still occur among us as they have occurred in all ages,' * the statements show the author to be so lacking in a comprehension of the principles of physics that he is unable to estimate whether or not a phenomenon of physics is likely or not likely to be true. It is clear that a man may be an authority as to biology, and yet be so ignorant of the rules of physics that he may be as simple as a child in reference to that subject. Upon the other hand, a man who has a firm understanding of the principles applicable to a case, or, in other words, knows the rules of the game, is likely to be able to reach a rather definite conclusion as to whether or not an explanation which suggested itself is in accordance with those rules, and therefore may be true, or disagrees with some of the well established rules, and therefore is not worth considering.

A geologist once said to me of my teacher and early geological guide, Professor Irving, that he was more correct as to the structure of the Lake Superior region than he ought to have been. But I say that every man is just as correct as to deduction beyond observed facts as he should be. Men with defective basal training and poor intellectual power will always fail when they try to put complex facts together under principles, and especially when they attempt to project by deduction beyond observed facts. But men who have a firm grasp of the principles of the sciences basal to geology, the capacity to correlate these principles and apply them to the facts of geology, will go beyond their observations and by deduction will reach conclusions with perfect confidence which are far in advance of observation. Indeed in this way only can the best geological work be done. After one has projected his deductions in advance of observations, he returns to the field with these new ideas, and then carries his observations farther than he was able to do before. The geologist whose ideas are not continually outrunning his observations will never go far in the science. He whose mind is behind his observations instead of in advance of them, will ever be mediocre. The minds of the leaders of geology are on the mountain heights before their feet have more than touched the foothills.

The conclusions deduced by a scientific genius may go so far in advance of observations that he who announces the conclusions may not be able to make observations which confirm the theories during his lifetime. In such cases subsequent observations made through many years by others will find the phenomena confirming the principles. The truths announced by men of insight are often not accepted by slower men until this later observational work is done. Many cases could be cited illustrating these statements. Darwin, in 1860, *knew* that life had existed that would fill in the great gaps in the very imperfect paleontological record. Since 1860 all the greater gaps have been filled by discovered fossils.

* 'The Wonderful Century,' by Alfred Russell Wallace, p. 211.

Mendeleeff, when he saw the law of the periodic arrangement of the elements, *knew* that elements exist which would fill the gaps; but it took many years of work by many men to find a part of them; and during the past few years a half dozen or more of the vacant places have been occupied. Each geologist, each scientist, now as in the past, is just as right as he should be. The scientific seers will ever go far in advance and guide others, even as did the spiritual seers of old.

The scope of these observations doubtless extends beyond geology. Much of what has been said is true of knowledge as a whole, not restricted to one subject. But I shall have accomplished my purpose if what I have said be true of geology; for if my conclusions be well founded, they furnish the basis upon which courses leading to degrees in professional geology should be laid out, and to methods of good geological work in the field and in the office.

C. R. Van Hise.
University of Wisconsin.

SECTION D, MECHANICAL SCIENCE AND ENGINEERING.

Papers were presented as follows:

The Trend of Progress of the Prime Movers: Professor R. H. Thurston, Cornell University.

1. The great prime movers have been known in type and in some cases, in specific forms,,still familiar, since the days of Hero of Alexandria and probably may have been in some forms known to prehistoric Greeks and Asiatics. The sources of power—heat, falling waters, the winds—all were well known when the earliest scientific writings were produced, and the famous Alexandrian 'Museum' contained illustrations and examples of even some of our simpler familiar types of steam-engine and steam-boiler.

2. The prime movers made little progress toward their present perfection until the commencement of the eighteenth century, when the steam-engine of Savery and Worcester, the old steam fountain of Hero the Younger, was displaced by the modern steam-engine, a real train of mechanism, devised by Newcomer, the inventor of the modern type of machine, about 1707. Meantime, water-wheels and windmills were taking form and the prime movers thus were preparing to do their part in the world. Improved by Watt, the steam-engine assumed the largest part of the load, but the water-wheels and windmills have always done a large amount of work in the aggregate. The industrial world came after a time to be moved as a whole by the prime mover of Watt, and steam power has of late performed vastly more work than could the whole population of the world, unaided.

3. The gas-engine has a history of about the same length as the steam-engine in its form of a prime mover for mills. It was introduced about a century ago and has progressed meantime less rapidly than its rival, but since the middle of the nineteenth century its advance has been steady, both in construction and in employment. To-day this motor has assumed a perfection of design and construction and has attained an excellence of economical performance which is rapidly bringing it into use in a great variety of fields and is, in fact, making it a promising competitor with the older motor.

4. The other motors have been meantime greatly improved. The modern hydraulic turbine has attained an efficiency of eighty per cent. and upward and the contemporary windmill is a scientifically designed, skillfully made apparatus of but little if any less perfection, for its purpose, or efficiency in utilizing its form of energy. All the common forms of prime movers have now, thanks to advances in sciences related to

engineering and to the progress of invention, become highly perfected and the next question of the engineer and of the employer of power has come to be: 'What new motor can be devised to more perfectly utilize the available energies of nature?'

5. The serious wastes of the best heat-motors are doubly serious and important in view of the fact that our coal deposits are of limited extent and that however great they may appear, that limit will be attained in one fifth of the time, even with the best practice of to-day, that would be secured could the wastes, now apparently inevitable, be extinguished. Our best steam and gas-engines waste four times as much of the thermal energies supplied them as they utilize. A substitute for these engines must be sought if they cannot be made thus practically perfect; but no way is known to which the purely thermodynamic wastes which constitute the greatest obstacle can be prevented.

6. Our existing stores of available energy may possibly be reinforced by more complete employment of the water-powers, the wind currents and the internal heat of the earth. Our present wastes of thermal energy might be reduced to comparative insignificance could a way be found of imitating nature in the complete utilization of the supply through other processes than thermodynamic. Nature actually does produce light without heat and apparently, at least, power without thermodynamic wastes; it would seem that man should be able to imitate her methods. If this could be done, our electric lighting could be provided or a substitute of similar value obtained that should reduce the wastes, as in the fire-fly and the glow-worm, with one four hundredth as much expenditure of energy as now is exacted in the production of light by our usual forms of illuminant. It would be possible to increase the amount of power derived from a stated quantity of potential energy four or five times. Heat drawn from the interior of the earth would provide us with what may be needed by man as long as man can live upon a cooling globe.

7. When the inventors and discoverers have thus performed their task, 'we shall be assured of a vastly longer persistence of civilization upon the globe, shall be able to employ mechanical power at a fraction of its present cost, shall secure light without heat and of a hundred times greater quantity at the same expenditure, shall distribute the electric current for whatever purposes at minimum expense, and shall make every civilized nation on the earth many times wealthier and shall extinguish poverty and, largely, crime.'

On Changes in Form as an Essential Consideration in the Theory of Elasticity: FRANK H. CILLEY, Engineer's Office, New East River Bridge, New York City.

While we perceive the necessity of recognizing and allowing for large distortions of elastic bodies under load, we are apt to think that, if the distortion be sufficiently small, it is negligible. We are apt to proceed on the supposition that changes in stress and deflection due to an added load are unaffected by the existence of other stresses at the time the load was applied. This is incorrect. Distortions, however small, may seriously modify the change in stress and deflection due to a given load. And the existence of other stresses at the time of the application of the load may be a most important consideration.

The consequences of small distortions may be fully taken into account by direct but highly mathematical analysis. But methods of approximation will usually answer the same end and be much simpler in single numerical cases. We have only to determine the distortion from the stresses as ordinarily found, and then recalculate the stresses for the changed form.

The cases in which this more exact procedure is most necessary are to be found chiefly among problems in thin plates, rods, trusses with very light webbing, arches and suspension bridges.

A simple case is the post under combined axial and transverse load. Standard posts may have bending moments and deflections a third to a half greater than they would were they simple beams. And this is equally true whether the end pressure be due to loads or to a stressed tie (primary stress).

The posts under combined axial and transverse loads are comparable to the parabolic arch ring under uniform load and bent by a concentrated load.

They are sufficiently slender to have materially increased stresses and deflections in consequence of their distortion.

Frameworks with sufficiently light webbing may have very different stresses and deflections from those determined by the usual methods. This is particularly the case with heavy bowstring trusses.

But the greatest divergencies in practice resulting from the application of the more exact analysis which takes account of small changes in form, are found in connection with suspension bridges. There the fundamental proposition of the usual analysis, that single loads on the stiffening truss cause a uniform increase in the suspender stresses, is sensibly in error and leads to many most incorrect conclusions.

To sum up, even small changes in the form of some structure have most appreciable consequences, and stresses existing at the time of the application of a load may most seriously modify its effects. These truths require more general consideration.

The Ratio of Direct to Transverse Change of Dimension under Longitudinal Stress (Poisson's Ratio): Professor Thomas Gray.

This paper consisted mainly of a description of the apparatus and methods of measurement employed in the determination of Poisson's ratio for metal bars.

The specimens used were round bars varying in thickness between one and a quarter and two inches. The stress, either tension or compression, was applied and measured by means of a Rhiele testing machine capable of applying a total load of 100,000 pounds. The lengths under test were usually either ten inches or sixteen inches, and the elongation or compression was measured by means of the author's autographic attachment to the machine (*T. A. S. M. E.*, Vol. XIII., 1892). The autographic record was omitted, the change of length as indicated by the magnifying levers being read, for particular loads, from a scale. The transverse change of dimension, which is much the more difficult to measure with accuracy, was obtained by means of a special calipering device contrived by the author of the paper and constructed in the Rose Polytechnic shops. This apparatus was carried by the specimen at the middle of the test length, in such a way that the points of contact of the caliper levers were at opposite extremities of a diameter and remained constant. The magnifying power was adjustable and could be made such that a change of diameter of less than one millionth of an inch gave a positive indication. The total change of dimensions which can be obtained, within elastic limits, is very small even for steel, being only about one three thousandth of an inch on a diameter of one inch.

It has been customary to infer the value of this ratio for separate determination of the Young's and the rigidity modulus of elasticity on the assumption that the material is nearly enough isotropic. One of the objects of this direct measurement was to test the reliability of this method of inference. If E be Young's modulus in the

rigidity modulus, and σ Poisson's ratio, the theory of elasticity gives, for an isotropic solid,

$$\sigma = \frac{E - 2n}{2n}.$$

Now for most metals E is about two and one half times n. Hence it is evident that a small error in the determination of E or n may be quite a large error in the inferred value of σ.

The results of the experiments in general were that for steel either hardrolled or annealed the results given by the above formulæ and those got by direct measurement are almost identical. In the cases of cast iron and alloys of the metals, however, the results obtained from the formulæ are not reliable. The following short table illustrates the results obtained by direct measurement:

Description of Specimens.	Diameter.	Ran ge of Lod in Pounds.	Young's Modulus.	Pois-on's Ratio.
Hammered tool steel 1.5 per cent. carbon, hard...	1.4985	50000	29.5×10^6	0.291
Hammered tool steel 1.5 per cent. carbon, annealed	1.4930	20000	29.5×10^6	0.291
Hammered tool steel 1.2 per cent. carbon, hard...	1.4988	50000	29.7×10^6	0.293
Hammered tool steel 1.2 per cent. carbon, annealed	1.5130	30000	30.0×10^6	0.294
Hammered tool steel 0.9 per cent. carbon, hard...	1.5513	50000	29.4×10^6	0.288
Hammered tool steel 0.9 per cent. carbon, annealed	1.4830	30000	30.0×10^6	0.295
Cast bronze 90 per cent. copper (compression)...	1.496	16000	10.8×10^6	0.297
Cast bronze 90 per cent. copper (tension).....	1.496	12000	10.9×10^6	0.303
Aluminum zinc alloy density 3.4.....	1.4979	7000	5.27×10^6	0.208
Aluminum zinc alloy density 3.5.....	1.2445	14000	7.79×10^6	0.290
Cast iron.....	1.7485	5000	13.27×10^6	0.258
Cast iron.....	1.7485	16000	11.81×10^6	0.245

Effect of Hardening on the Rigidity of Steel: PROFESSOR THOMAS GRAY.

Attention was called to this subject some months ago in a paper read before the American Society of Mechanical Engineers by Professor C. H. Benjamin. The principal subject in that paper was the resistance to compression of helical springs. Incidentally it was stated that the modulus of rigidity derived by calculation from these experiments was much higher than that usually given in the published data for steel. This seemed contrary to my experience, but on looking for direct evidence on the subject no record could be found. In consequence a few specimens of steel, containing different amounts of carbon, were prepared and tested directly for rigidity in their original state, and also after hardening by heating to redness and quenching in water. The results are given in the tabular form below. The percentages of carbon in these specimens were not determined as the exact amount did not seem of any importance. Specimen No. 3 had just carbon enough to admit of hardening.

The results show the effect of hardening

Kinds of Steel.	Diameter in Inches.	Length Under Test in Inches.	Modulus of Rigidity.
High carbon tool (soft).....	1.430	12.24	11.61×10^6
High carbon tool (hardened).....	1.430	12.25	11.46×10^6
Medium carbon tool (soft).....	1.444	12.27	11.67×10^6
Medium carbon tool (hardened).....	1.445	12.30	11.56×10^6
Low carbon tool (soft).....	1.4895	12.06	12.32×10^6
Low carbon tool (hardened).....	1.4895	11.44	12.23×10^6
Low carbon tool (blue tempered).....	1.4895	11.90	12.27×10^6
Special tool 1.5 per cent. carbon (soft).....	1.4930	16.63	11.58×10^6
Special tool 1.5 per cent. (hardened).....	1.4900	16.27	11.51×10^6

on the rigidity to be small but instead of a large increase it is a diminution.

The Advantages of Siamesed Hose Lines for Fire Steamers: Mansfield Merriman. Lehigh University, South Bethlehem, Pa.

The method of using several parallel lines of hose from a fire steamer to a siamese joint is explained, and formulæ for the discharge and effective velocity head of the stream from the nozzle are established. The effects upon the discharge and velocity-head of two, four and six lines of hose are illustrated by practical examples and exhibited graphically. The great increase caused by two or three lines is noted, as also the much smaller increase caused by additional lines. It is shown that more than six lines are rarely advantageous and that four lines probably give the best practical results. In conclusion the author briefly notes and compares the analogy between the formulæ for the common and viscous flow of water in pipes laid in parallel with that for the flow of electricity in metallic conductors.

The Nomenclature of Mechanics: R. S. Woodward, Columbia University, New York.

The object of this paper is to advocate the desirability of adopting definite and unique meanings for the principal technical terms of mechanics, of discarding all secondary meanings of such terms, and of inventing new terms when essential to distinguish mechanical principles and properties differing from one another.

On a Type of Planetary Orrery Utilizing the Mechanical Principle of the Conical Pendulum: David P. Todd, Director of the Observatory of Amherst College.

This machine is intended to employ the principle of the conical pendulum. Pendulums of different length, suitable to the revolution periods of the planets, are attached at the upper end to concentric arbors, properly geared; the spheres representing the planets are attached to the lower and outer ends of these pendulum rods. In this way the relative periods of revolution of the planets and their sizes can be conveniently illustrated mechanically on as large a scale as may be desired.

The Viscous Dynamometer: J. Burkitt Webb.

Some years since the author designed an absorption dynamometer depending on the viscosity of water for use in testing the Whitehead torpedo and the results were published in the *Stevens Indicator*. In the use of it a very convenient property which it possessed was discovered, namely, that a sufficiently exact relation existed between the moment tending to rotate it and the number of revolutions, to make it possible to get the horse-power from an observation of the moment only. This was especially valuable in Whitehead torpedo work on account of the engine running but a short time.

The dynamometer was redesigned three or four years ago for testing turbines for electric light work and is now used largely for that purpose. The one first built consists of two steel disks (circular saw blanks) mounted on a horizontal revolving shaft on which is journaled a cast-iron case enclosing the disks and supporting a stationary disk between them. The sides of the case are also turned true so that each revolving disk has a fixed surface about one eighth of an inch distant from it. The case is supplied with water which is allowed to run slowly through it to prevent a rise of temperature, and means are provided to regulate the amount of water in the case, which is kept by centrifugal force in annular layers or disks at the other part of the case cavity. The shaft being now connected with a source of power of sufficient speed, the viscosity of the layers of water tends to

carry the case and fixed discs around with it, which being prevented by a spring balance attached to a radical projection from the case, the moment is readily obtained.

Various interesting facts developed themselves in the use of this instrument and experiments in progress by a large electric company confirm the theoretical formulas for the moment by which the dynamometer can be correctly designed.

The horse-power absorbed is adjustable by varying the amount of water retained in the case, which is easily done.

A specially interesting thing was the effect of handling the water entering the dynamometer; let the hands be wiped (not washed) ever so carefully, after handling the ordinary slightly greasy tools and parts of machinery, and held under the stream of entering water, there would be an immediate reduction of the moment by about ten per cent.

As an illustration of the effectiveness of this dynamometer it is sufficient to say that the two revolving disks two feet in diameter absorbed the whole one hundred and ninety horse-power of a turbine of twice their diameter.

The Dynamophone, a new Dynamometer: J. BURKITT WEBB, Stevens Institute, Hoboken, N. J.

The dynamophone is a new form of transmission dynamometer. In a large number of cases when power is to be measured mechanically it is done by observing the extent to which some elastic substance yields and deducing therefrom the stress caused in it by the transmission of the power to be measured. Power is transmitted mechanically mainly by rotating mechanism, and such transmission is invariably accompanied by a *change of phase*, that is, the driven part lags behind the part that drives. The simplest and most common example of this is an ordinary line of shafting in which we have only to determine the torque and number of revolutions to find by their product the energy transmitted. About 1880 I was working under the direction of Professor Helmholtz upon the change of phase in an alternating current in a circuit containing an electrolytic cell as well as resistance, capacity and inductance, and invented an apparatus (of which the dynamophone is a modification) for making and measuring a difference of phase. After my return to the United States this remained packed away, until recently the problem of measuring the power transmitted to a marine propeller presented itself. The motor being an improved form of turbine, the ordinary steam-engine indicator could not be used, and so a portion of the shaft was prepared for the purpose and exactly calibrated by ascertaining the torque required to twist it from one degree up to ten degrees. To measure the twist of the shaft when revolving from 400 to 700 times a minute and transmitting from 100 to 2,300 horse power the dynamophone was successfully employed and in the following manner:

Upon each end of the calibrated length of shaft a wheel twelve inches in diameter was mounted, having 36 teeth. In front of each wheel a telephone magnet and coil was supported, the axes of the magnets at right angles to the shaft. The ordinary vibrating disks of the telephones were thus replaced by the toothed wheels, which thus induced in the telephone circuits a musical tone the strength and quality of which could be adjusted by screws which varied the distance of the magnets from the wheels. These telephones were further mounted so that they could be revolved about the center of the shaft with a scale and microscope to measure their angular position, and such a revolution must of course change the phase of the tone vibrations. To compare the phases of the two telephones, their circuits were connected in series with one (or

more) receiving telephones, so that one (or more) observers could hear the combination or algebraic sum of the tones. Now the tones being adjusted to equal strength by the adjusting screws and to the opposite phases by revolving one of the mounted magnets, the receiving telephone gave no sound, and this condition of things was evidence that the teeth at both ends passed before their magnets at the same time. Now the zero having been determined with the propeller disconnected, it remained only to observe the angle through which the observing magnet had to be moved when the shaft was running under torsion, to have a measure of the twist of the shaft.

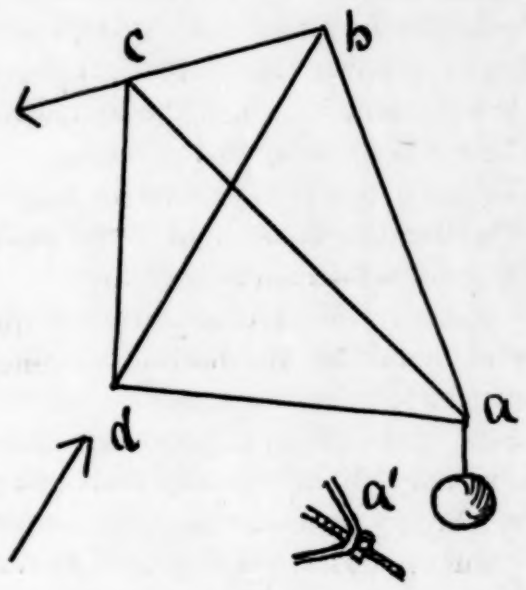
The apparatus gave perfectly accurate results with a precision of from one quarter to one per cent. The zero was readily and certainly obtained by a particular method of observation and in spite of the noises of the running machinery, and the results required only a single multiplication to give the horse-power corresponding to any particular observation. A model of the dynamophone was exhibited to the Section, with photographs connected with a recent test of the new turbine yacht *Revolution*.

The Deflection of a Complete Quadrilateral: J. Burkitt Webb.

The object of this paper is to outline a method which I have used for some years at Stevens Institute for investigating the stresses in framed structures with superfluous members. Suppose we consider *ac* as superfluous and imagine the joint *a* to be constructed as indicated in the figure.

Now remove the weight and screw up the nut until the perfectly definite stresses thus produced in the members amounts to some convenient amount, say a tension of minus 40 in *cb*. An ordinary force polygon is then drawn, giving the corresponding stresses in the members, and, the material and dimensions being known, the strains due to these stresses are tabulated for all the members.

This primary part of the process is completed by finding the displacements of all the joints and the lower end of *a* by means



of a displacement polygon (treated of in a paper before Section A), which gives the *distance* which the nut must be screwed up to produce the assumed stresses.

Secondly, the nut is run down entirely out of the way and the weight put on to produce a stress of plus 40 in *bc* and another force polygon is constructed with its corresponding deflection polygon.

The final operation is to screw up the nut any desired distance and then add the stresses thus produced to those already due to the weight. Evidently the final stresses consist of the weight stresses plus the primary stresses multiplied by a fraction, the denominator of which is the distance determined as corresponding to the minus 40 in *bc*, and the numerator of which is the distance the nut may be finally screwed up.

A New Photometer for the Measurement of the Candle-power of Incandescent Lamps: Professor C. P. Matthews, Purdue University.

Nearly every one in this age of electric

lights knows that the familiar incandescent lamp is made in several sizes of different brightness or candle-power. The common size yields nominally a light in the direction chosen for rating equal to that emitted by sixteen standard British candles. The light emitted in other directions depends on the form in which the filament is coiled. Now, it is possible for each of two lamps to yield light in the measured direction of 16 c. p. intensity, and yet to produce quite different total amounts of light. This means that the lamps, although nominally of the same candle-power, are actually of quite different power as producers of general illumination.

Clearly the only true criterion of the worth of lamps as producers of light is the average light produced in all directions. This value is called the mean spherical candle-power.

A new form of photometer has been devised by Professor C. P. Matthews, of Purdue University, that gives this value with the ease and simplicity of the ordinary photometric measurement. A double ring of mirrors produces on one side of the photometer screen an illumination proportional to the mean spherical candle-power of the lamp to be tested. This illumination is balanced or equalized against that due to a light of known candle-power at a distance that can be read from a convenient scale. The instrument is adapted to all forms of photometric measurements or incandescent lamps, gas flames and sources of like intensity.

The Proposed Air-ship Contests at the St. Louis Fair: CALVIN WOODWARD, Washington University.

It is the expressed opinion of many, perhaps the conviction of most people, that nothing ever will be accomplished in the way of aerial navigation that is of permanent commercial or social value. It is admitted that balloons may furnish valuable positions for observations in war, but no air-ship will ever be able to make trips to and fro, carrying either freight or passengers. With all due respect to such people, the author is bound to differ. They beg the question. He freely admits that the problem has not been solved; that our appliances for the transformation and utilization of energy are at present inadequate; even the line along which progress is to be made has not been fully determined; but he has no doubt of the result. It may, and probably will, take many years, but there is plenty of time, and even the wisest of us 'do not know it all.'

History ought to teach us something of the proper attitude toward unsolved problems. It will be remembered that a commission consisting of the most eminent of the engineers of England headed by Rennie opposed the use of the locomotive on the first complete railroad, but Stephenson persuaded the owners of the Liverpool and Manchester road, who had expected to pull their trains by cables moved by stationary engines, to offer a prize of $2,500 for the best locomotive and to open the competition to the world. The result was the entry of five engines, among which was the victorous 'Rocket' which demonstrated the possibility of a successful railroad locomotive. The result proved the great value of an open competition.

Scientific men sometimes nod. Professor Lovering, afterwards President of the American Association for the Advancement of Science, when Cyrus W. Field was preparing to lay the first Atlantic cable, in a lecture to the author's class at Harvard, proved the utter impossibility of telegraphic communication under an ocean 3,000 miles wide.

The Executive Committee of the Louisiana Purchase Fair believe that progress in aerial navigation is possible and they have

proposed to stimulate it. They have decided to offer liberal prizes and to enforce conditions which will call out the best efforts of the best investigators.

They specify no device or machine; they base everything on performance, on a return course requiring a high degree of control. They have fixed a minimum which greatly exceeds any recorded maximum.

Before reading their rules the author wishes to call attention to two considerations touching the possibility of progress and the probable line of approach.

Rapid progress is being made in the matter of reducing the weight of prime movers per horse-power. The diminution of the steam-boiler, as shown by the gas-engine and the Diesel motor, has made it quite possible to construct an engine as strong as a horse and as heavy as a goose. Human ingenuity will surely suffice sometime to enable such an engine to fly.

The skillful teacher at the swimming school gently buoys up the novice while he learns how to move his arms and legs. As his pupil masters the movements and coordinates the strokes he needs less and less of help from the fish-pole and line of the instructor, and soon he swims without assistance and to his great surprise.

Will it not be so with the navigator of the air? At first he needs the buoyancy of a balloon attachment while he elaborates his propellers, planes and guides. As these increase in efficiency the balloon attachment diminishes, until finally it may disappear altogether. Who can say it will not? The writer has no hope from the balloon pure and simple. He has at present small hope of a pure flying machine; but he has great hope of a device which, while flying, accepts more or less aid from a buoyant gas.

New Methods of Experimentation in Aerodynamics: A. F. Zahn.

In this paper Zahn outlines some researches in aerodynamics by Mr. Mattullath and himself at the Catholic University of America. Their investigations cover a variety of subjects important to the science of practical dynamic flight, but the paper is confined mainly to the description of a new laboratory and equipment for generating a uniform rectilinear flow of air and measuring its effects upon various models and shapes of scientific and practical interest—in other words, the description of an aerial 'model basin.'

In a special building erected on the campus by Mr. Mattullath is a wooden air tunnel fifty feet long by six feet square in cross sections, having a five-foot suction fan at one end and a netting or two of close mesh at the other. A wind is thereby generated of practically uniform velocity and direction, the speed varying less than one per cent., the direction but a small fraction of a degree. In this current are held objects whose lift, drift, skin-friction, etc., are to be measured.

A general description is given of the apparatus for generating and controlling the wind, the devices for proving its uniformity of velocity and direction, the instruments for measuring its effects on immersed bodies. Among the various anemometers and wind balances designed is a pressure gauge graduated to millionths of an atmosphere, and which may be adjusted to read to less than one ten-millionth. It is connected by hose to one or more Pitot nozzles, and is used to measure the air velocity and pressure at all points of the stream, particularly in the neighborhood of the exposed body.

The results of each investigation will be given in technical detail in a series of papers, excepting those that are withheld for business reasons. The prime motive of these researches is to furnish a basis for

calculations in aeronautics, particularly in the theory of mechanical flight.

Long Distance Electric Transmission Regarded as a Hydrodynamic Phenomenon: HENRY T. EDDY, University of Minnesota. (A full abstract will be published later.)

The Effect of Weeds and Moss upon the Coefficients of Discharge in Small Irrigating Canals: J. C. NAGLE, College Station, Texas.

This paper gave the results of a half dozen measurements made during the summer of 1901 upon small irrigation canals discharging from about three and one half to twelve cubic feet of water per second, and will show the retarding effect of moss and weeds in some of the canals.

The Compound Pendulum: ALBERT KINGSBURY, W. P. I., Worcester, Mass.

The paper referred especially to a diagram by means of which the relations between the centers of suspension, of gyration and of oscillation are graphically determined; the identity of centers of percussion and of oscillation; the interchangeability of centers of oscillation and of suspension; the position of the axis of suspension for minimum time of small oscillations; and the two cylinders of positions of the axis of suspension for any given time of oscillation.

Crushed Steel and Steel Emery; an Artificial Abrasive produced from Steel: M. M. KANN.

The Mechanics of Reinforced Concrete Beams: W. KENDRICK HATT.

A Test of a Ball Thrust Bearing: THOMAS GRAY.

Determination of the Exponent in the Equation pv^n of Heat Engine Indicator Diagrams: W. T. MAGRUDER, Ohio State University.

Some Experiences with a Simple Babbett Testing Machine: E. S. FARWELL, New York.

In order to select the most suitable babbett metal for use in paper mills a series of tests were undertaken with a machine consisting of a three and one fourth-inch mandril rotated at about 775 revolutions. The test block was held against the bottom of this mandril by a long bent lever to which weights were applied. The block and mandril were immersed in oil. After a number of failures which are described, and the discovery that the readings of the thermometer were vitiated by the heat from the main bearing the machine was remodeled. As remodeled it consisted of the same mandril and two test blocks held against opposite sides by a pair of levers acting like nut crackers. The weights were added to the outer end of the upper lever, while the outer end of the lower lever rested on a platform scales. The other end of the levers was counterbalanced so as always to produce an equal pressure on both blocks. As thus reconstructed the coefficient of friction may be determined as well as the breaking load. Observations on several methods of lubrication are given as well as other experiences with this simple but accurate testing machine.

Notes on the Electrical and Mechanical Equipment at the Charleston Exposition: J. H. GRANBEY, Elizabeth, N. J.

A short paper giving a résumé of the data regarding operation and equipment of the exposition at Charleston, S. C. Some details of interest in the installation of temporary underground lines are given, and attention is called to some departures from the accepted practice in engineering work, used for special features.

The following papers were presented by title:

U. S. Work in the Ohio, Allegheny and Monongahela Rivers near Pittsburgh: Thomas P. Roberts.

C. A. Waldo,
Secretary.

SECTION F—ZOOLOGY.

At the first morning session on Monday, June 30, 1902, in the absence of Vice-President Charles C. Nutting, of the State University of Iowa, the meeting was called to order by Professor Henry B. Ward, and Professor Carl H. Eigenmann was elected temporary chairman.

In the regular order of business, the following elections were made to the positions mentioned:

Member of the Council: Dr. W. J. Holland, Pittsburgh, Pa.

Members of the Sectional Committee: Professor Charles W. Hargitt, Syracuse University; Professor Henry F. Osborn, Columbia University; Professor F. M. Webster, Wooster, Ohio.

Member of the General Committee: Professor Herbert Osborn, Ohio State University.

Press Secretary: Dr. Ch. Wardell Stiles, U. S. Dept. of Agriculture.

At the afternoon session the meeting was called to order by the Secretary.

In the absence of President David Starr Jordan, his vice-presidential address was presented by Professor Carl H. Eigenmann. The secretary announced that the Sectional Committee had elected Professor E. L. Mark, Harvard University, to serve as vice-president during the Pittsburgh meeting.

At the morning session, on July 1, Professor E. L. Mark in the chair, the following papers were presented:

A New Microscopical Cabinet, Made of Metal: Charles Sedgwick Minot, Harvard Medical School.

A metal cabinet containing metal trays for microscopical specimens was exhibited. It has the advantage of being relatively safe from fire, and much more compact than wooden cabinets, and is therefore recommended especially for permanent and valuable microscopical collections. The case is made of tin japanned, and the trays also. Each tray is made with a double bottom to prevent warping and has space for twenty-four 3 x 1 slides. Each cabinet, having thirty trays, will take 720 slides. The cabinets cost $12.50 each and may be obtained from Peter Gray and Son, 11 Marshall Street, Boston. (Discussed by E. L. Mark.)

Insect Enemies: A Matter of Taste: Francis M. Webster, Wooster, Ohio. (Will appear in *Entomological News.*)

The speaker gave an account of experiments in feeding living insects to mice, and called attention to the fact that distasteful insects are not always rejected by all individuals of the same species of bird.

Remarks on the Finding of Bones of the Great Auk in Florida: Oliver Perry Hay, American Museum of Natural History. (Will appear in full in *The Auk.*)

The speaker stated that bones of the great auk were found in a shell-mound at Ormond, Fla. He described the situation and character of the mound and discussed the probability of the bird's having lived in that region. (Discussed by L. L. Dyche.)

Variation Among Hydromedusæ: Charles W. Hargitt, Syracuse University.

A continuation of earlier observations on this subject confirms the conclusions published elsewhere by Dr. Hargitt and extends them to other genera and species. An examination of several hundred specimens of *Coryne mirabilis* confirms the statements of Bateson relative to the remarkable constancy of this medusa, since not the slightest variation was noticed in any essential organ. The trachomedusa, *Trachynema digitale,* showed the comparatively low ratio of eight per cent. in total

variations, chiefly in radial canals and gonads. *Rhegmatodes tenuis*, a leptomedusa, presents a much higher ratio of variation, no less than twenty per cent. showing more or less marked variation in character and size of radial canals. In this species a rather prominent variation was that of the bifurcation, looping and anastomosing of the canals, suggesting a probable means by which the large number of canals may have arisen. The speaker has already called attention to a similar condition in *Gonionema* as has Mayer in *Pseudoclytia pentata*. Variation of the gonads followed a similar range, but in view of the comparatively immature condition of many of the specimens, no attempt was made to go into details upon this point.

The Sense of Taste in Fishes: C. JUDSON HERRICK, Denison University.

Sense organs known as terminal buds, which resemble taste buds in structure and are wholly independent of the lateral line system of sense organs, are found freely scattered over the entire body surface of the catfishes. Like the taste buds in the mouth, they are innervated by communis nerves and presumably they serve the gustatory function. To test this hypothesis experiments were performed to determine how the siluroid fishes perceive their food. It appears that the sense of sight plays very little part, the sense of smell and the sense of touch considerable parts, but the sense of taste clearly the chief part in their detection of food. These fishes appear to taste not only in the mouth, but by contact with sapid substances by the barblets or the skin of the body at any point as far back as the root of the tail fin. Gustatory and tactile sensations arising in these cutaneous areas commonly cooperate in evoking the reflex of seizing food, but by training the fishes can be taught to discriminate between the gustatory and the tactile elements in the stimulus and to respond only when both are present, ignoring simple tactile contacts. Some other fishes with large eyes and having these terminal buds less generally distributed over the body surface feed in a wholly different way, by snapping up a moving bait (visual stimulus), as every fisherman knows. (Discussed by Messsrs. Dyche, Eigenmann and Surface.)

On the Value of an Apparently Fixed Food-Habit in Scale Insects as Determining Species: CHARLES LESTER MARLATT, U. S. Dept. of Agriculture.

The speaker detailed striking variability in the food habits of certain species of scale insects; food plants of the same species in different districts may be multiple or single, and may change from year to year or after a series of years, the plants once attacked becoming practically exempt and new host plants being assumed. A fixed food habit could not, in the opinion of the speaker, be considered as necessarily of value in determining species. (Discussed by Messrs. Webster and Hopkins.)

Statistical Study of Variation in the Periodical Cicada: HERBERT OSBORN, Ohio State University.

A distinct variation from the typical form of *Cicada* (*Tibicen*) *septendecim* has been recognized since 1829, and was described in 1851 as a distinct species, *cassini*. Riley, however, and later Marlatt have concluded it should be ranked simply as a dimorphic variety. In the occurrence of the present year this form has been so very abundant that a statistical comparison of the two forms was naturally suggested. Measurements of 800 specimens show a very decided constancy of each variety and for each sex of each variety. This constancy can best be shown in curves of frequency. Color variation is also very constant and is believed to be as constant as the other fea-

tures which can be represented in actual measurement. A very distinct difference in the note is observable and has been frequently mentioned in previous records; a fact that must be borne in mind as not only meaning some difference in morphology of sound-producing organ, but in controlling the selection of mates.

Special effort was made to observe the copulations and determine whether any efforts were made at crossing between the two forms. In all the specimens taken in coitus and which have been reported by others not a single instance of such crossing has been observed.

This has been the uniform instance of previous observers who have made observations on this point, and is evidently very uniform and shows distinct sexual selection; that is, we have here a very evident case of isolation due to sexual selection, and it would appear on this basis every opportunity for perpetuation of the variety.

No evidence of 'dimorphism,' as Professor Osborn understands the term, seems to be available from any source. It is certainly not seasonal or sexual, and if, possibly, a depauperate form, we would not term it dimorphic unless it can be proved that it may alternate with normal forms.

It may be said in summary that: (1) There is a very constant color difference; (2) measurements show very close adherence to two entirely different averages for length of body, length of wing and width of wing. This is best shown in curves. (3) There is a totally different note characteristic of each form, which must be considered as representing different morphology of sound-producing organs as well as basis for selection of mates. (4) No *cassini* forms have been found paired with normal forms and none have been recorded or have been reported. (5) There is a difference in genitalia though perhaps not enough to exclude the possibility of mating and Riley says the differences are not constant.

The fact that the two forms appear simultaneously or practically so in the seventeen-year period and have so many points of resemblance is certainly good evidence of very close relationship, and it would seem safe to say that they have sprung from a common and rather recent ancestral form or very likely that one is a derivation of the other which still represents the ancestral form for both, and taking data now available it appears more likely that *cassini* is the derived form.

The *cassini* form appears especially prominent in the brood XXII. so widely distributed the present year and, in my own experience, has been very rare in broods V. and XIII.

A variation possibly indicating another type is noted, though represented by only two specimens. (Discussed by Messrs. Marlatt, Hargitt, Hopkins, Webster and Ortmann.)

The Animal Ecology of Cold Spring Beach, with Remarks on the Theory of Adaptation: Charles B. Davenport, University of Chicago. (In absence of author, read by title.)

Cold Spring Beach is a sandspit near the head of Cold Spring Harbor, L. I. An outer harbor of strong erosive currents and an inner quiet harbor of deposition are separated by it. In the submerged beach is a shallow water fauna of sessile lamellibranchs, burrowing molluscs and worms, crawling and burrowing crustaceans and molluscs, and swimming predaceous animals, chiefly fish. The struggle here is so keen that certain marine forms (*Orchestia, Littorina*) have been forced to the terrestrial beach. The outer lower terrestrial beach is covered with microscopic débris and occasional decaying molluscs. Collembola cover its stony surface, chiefly arctic forms

of *Isotoma* and *Xenylla*. They burrow as the tide rises. In the outer middle beach is found the débris left at high tide, and this is feasted upon by scavengers, these scavengers in turn by predaceous forms of various orders of strength and swiftness. The tip of the sandspit is a region of currents where lamellibranchs thrive, attached to and protecting masses of *Spartina*. The inner beach supports numerous fiddler crabs. The animals form a society, the members of which are all there for some assignable purpose. The paper closed with a discussion of an auxiliary theory of adaptation, called segregation in the fittest environment.

Observations on the Mouth Structure of Scale Insects: JOHN B. SMITH, Rutgers College. (Will appear in full in Bull. 159, N. J. Experiment Station.)

The mouth parts of scale insects have been figured as three slender bristles or lancets for the adult and as a looped structure for the larva. The three bristles are regarded as mandibles and united maxillæ; but the nature or use of the larval loop has not been explained so far as the author's literature could inform him. The author regards all the bristles as maxillary and finds that the loop is used as a reserve length of tubing to keep the insect at all times in touch with its food. The bristles pass beneath the galear remnant and, forming a loop, return through a chitinous tube in the galea and are then forced into the plant tissue. The specimens studied were mostly prepared and mounted by Mr. E. L. Dickerson in securing material for a graduation thesis. (Discussed by Messrs. Marlatt, Mark, Webster, Osborn and Needham.)

Early Development of the Rock Barnacle, Balanus: M. A. and ANNA N. BIGELOW, Columbia University. (In the absence of authors, read by title.)

The authors described the early development of rock-barnacle, *Balanus,* dealing primarily with the subject from a standpoint of cell-lineage. Contrary to previous accounts, they maintain that the cleavage is regular and determinate. The germ-layers are traced from the early stages of the cleavage, and the development is shown to be closely similar to that of barnacles of the genus *Lepas.*

AFTERNOON SESSION, JULY 1. PROFESSOR E. L. MARK IN THE CHAIR.

Wind and Storms as Agents in the Diffusion of Insects: FRANCIS M. WEBSTER, Wooster, O. (Will appear in full in the *American Naturalist.*)

The speaker called attention to the several influences of winds on the diffusion of insects both independently of and in connection with thunder-storms. (Discussed by Messrs. J. B. Smith, Surface, Minot, Dyche and Bowlus.)

The Blind Fish of Cuba (with lantern slides): CARL H. EIGENMANN.

There are two species of blind fish found in the sink holes leading down to the underground streams draining to the south between Artemisa, Province Pinar del Rio and Alacranes, Province Matanzas. These fish are immigrants from the sea. They are viviparous; the young are about an inch long and four in number per gestation. The unborn young and the recently born individuals are colorless and possess well-developed but small eyes. The fish acquire color with age and the eyes very probably degenerate; at least they become covered with a thick layer of tissue. (Discussed by Professor Surface.)

The Problem of Getting Air, and How it is Solved by Aquatic Insects (with lantern slides): JAMES G. NEEDHAM, Lake Forest College.

The primitive terrestrial insect, with its

impervious cuticle, its spiracles and its system of internal air tubes, would seem, of all animals, the least likely to be able to take to aquatic life. Yet the adaptation has been successfully carried out on many different lines.

This paper set forth the diverse types of devices that have enabled insects to reinvade the water—the primitive home of animal life—and to become in shallow fresh waters a chief part of its fauna. Aquatic insects fall naturally into the following ecological groups:

A. Forms breathing air directly.
  a. Living on the surface; water striders, spring tails, etc.
  b. Resting beneath the surface; foraging down below, carrying down a reserve supply of air, diving beetles, back swimmers.
  c. Remaining down below, but in communication with the surface; *Ranatra*, rat-tail larvæ, etc.
B. Forms breathing the air dissolved in the water (strictly aquatic).
  a. Free swimming—*Corethra* larvæ, etc.
  b. Ambulatory.
    1. Climbing and clinging forms.
    2. Sprawling forms.
    3. Burrowing forms.

Of the strictly aquatic insects there are:

1. Gill-less forms (living in well aerated water: size small).
2. Forms with lamellate tracheal gills. May fly and damsel fly nymphs.
3. Forms with filamentous tracheal gills, stone fly nymphs, etc.
4. Forms with blood gills, and hæmoglobin in the blood.
5. Forms with tube gills. *Simulium* pupæ.

(Discusssed by Messrs. Osborn and Surface.)

The Habits of Fresh-water Lampreys (with lantern slides): Harvey Adam Surface, Pennsylvania State College.

The speaker presented numerous lantern slides illustrating his paper 'Removal of Lampreys from Interior Waters of New York,' published in the fourth Annual Report, Commissioner Fisheries, Game and Forests of New York. (Discussed by Dr. O. P. Hay.)

The Significance of the Recent American Cases of Hookworm Disease (uncinariasis or anchylostomiasis) in Man: Ch. Wardell Stiles, U. S. Dept. of Agriculture. (Will appear in full in the Annual Report, Bureau of Animal Industry for 1902.)

The speaker maintained that hookworm disease in man in this country is due to two different organisms; one of these, known as *Uncinaria duodenalis*, has been imported from Europe and Africa, and is now being imported by the troops who are returning from the Philippines; the other organism, however, is distinctly American, and is known as *Uncinaria americana*. This parasite has thus far been found in Virginia, Texas, Cuba and Porto Rico, and the indications are that it is more or less widespread in the southern states. The evidence at his disposal leads to the well-grounded suspicion that a number of cases of anemia in the southern states, which have heretofore been attributed to malaria and which have not responded to the regular treatment for malaria, are in reality cases of hookworm disease. He further exhibited specimens of allied parasites which cause similar diseases in other animals, such as dogs, cats, sheep, cattle, wolves, seals, the blue fox, etc. The so-called typhoid fever of cats, for instance, has been traced to one of these parasites, and is totally distinct from typhoid fever in man. One of these parasites also produces a very serious and often fatal disease among dogs, another is responsible for the death of many sheep in the southern states, and still another is responsible for the death of many young seals. The paper in question formed an illustration of the important relation which zoology bears to modern medicine. (Dis-

cussed by Messrs. Webster, Ward, Eigenmann and Hay.)

A Remarkable Turtle from the Loup Fork Beds of Kansas: OLIVER PERRY HAY, American Museum Natural History. (Will appear in full in *Bulletin Amer. Mus. Nat. Hist.*)

The turtle in question was one of Cope's species, *Testudo orthopygia,* which possesses an armor of bony plates in the skin of the legs, tail, etc. (Discussed by Professor Ortmann.)

MORNING SESSION, JULY 2. PROFESSOR E. L. MARK IN THE CHAIR.

The Harvard Embryological Collection: CHARLES SEDGWICK MINOT, Harvard Medical School.

The speaker described the methods used in the formation of the Harvard Embryological Collection, the general plan for which was laid before the Association at its Detroit meeting. The collection since then has grown steadily, until it now contains 527 series, representing carefully chosen stages of embryos of nineteen typical vertebrates. It has already served as the basis of a series of investigations, and it is hoped that workers from other institutions will also use the material for their special researches. The collection is being added to at present with considerable rapidity. The two types, of which the series at present are most complete, are the dog-fish, *Squalus acanthias* and the chick. (Discussed by Dr. H. B. Ward.)

Effects of Altitude on Snails of the Species Pyramidula strigosa Gould: MORTON JOHN ELROD, University of Montana.

The shells belonging to this species are air-breathing and land forms. The species is widely distributed west of the Rocky Mountains, as yet found in only a few places east of the main range. It shows very great variation. Formerly many species were recognized, but these have lately been reduced to varieties. The paper is based on specimens collected in western Montana. These were taken at altitudes varying from 2,300 to 9,000 feet. The total number examined was nearly 550.

The measurements included the greatest width, least width, depth, number of whorls, weight, volume and markings. The results show that the shells have even greater variation than was at first supposed. The extremes in greatest width are 6 and 25 mm.; in least width, 5 and 22 mm.; in depth, 3 and 17 mm.; in whorls, 3.5 and 6.5; in weight, .1 and 1.2 g.; in volume, .1 and 1.7 c.c. The greatest variation was found at lower altitudes, the high altitude forms showing a more fixed condition, with least tendency to deviate from the typical form. All the lines of variation shown in the tables for lower altitude shells show a tendency to vary from the typical form at a given place. From a study of the specimens secured it seems evident that the species has crossed the range and is now descending on the eastern slope. Specimens collected from the eastern or Atlantic side of the range are quite different in appearance from those on the Pacific side, being noticeably of greater depth, and with characteristic shell appearance and markings.

Structure of the Pelvic Girdle in the Sauropoda: JOHN BELL HATCHER, Carnegie Museum.

The speaker discussed the various elements of the pelvis of *Diplodocus, Brontosaurus* and *Morosaurus,* the three most common and characteristic genera of sauropod dinosaurs. The distinctive characters shown in the pelvic girdles of these three genera were illustrated and the view maintained that many supposed generic characters exhibited in the pelvis of the Sauropoda are in reality due entirely to differences of age, hence are of little value

for purposes of classification. The speaker also discussed the structure of the pelvis of the Sauropoda with relation to the theory as to the origin of the group from bipedal dinosaurs. (Discussed by Dr. C. S. Minot.)

A Record of the Occurrence of Filaria loa, a Human Parasite new to the United States: Henry Baldwin Ward, University of Nebraska.

The speaker cited a case of the occurrence of this thread worm, giving an account of the clinical history, the wanderings of the parasite, etc. (Discussed by Messrs. McMillan, Marlatt and Stiles.)

Notes on Some Cretaceous Fish from Kansas: Oliver Perry Hay, American Museum Natural History. (Will appear in full in *Bulletin Amer. Mus. Nat. Hist.*)

The speaker discussed especially the genera *Protorphyræna* and *Anogmius,* mentioning new features in their structure and presenting conclusions concerning the relationships of the organisms in question.

Morphology of Insect-galls: Melville T. Cook, Greencastle, Ind.

The speaker stated that the morphological character of a gall depends upon the insect producing it, and not upon the host plant. Galls produced by insects of the same family show a resemblance, and those produced by insects of the same genus show a decided resemblance. In some cases galls similar in character are produced by insects of widely separated genera. This is probably due to the fact that the insects affect corresponding tissues of the host plant. The insects always affect the active growing parts of the plant. It was stated further that many of the so-called 'stem-galls' are in reality bud-galls. In these cases also it seems probable that the insects affect corresponding tissues of the host plant. The Cecidomyid galls show the greatest variation, both in external characters and in histology. The Cynipidid galls show the highest development, both in external characters and in histology. (Discussed by Mr. Marlatt.)

In the absence of the authors the following papers were read by title:

Plankton Pulses: Charles Atwood Kofoid, University of California. (No abstract presented.)

Fish Remains of Oriskany Sandstone, Chapman Plantation, Aroostook County, Maine: Olof O. Nylander, Caribou, Maine.

A New Fresh-water Isopod of the Genus Mancasellus, from Indiana: Harriet Richardson, Smithsonian Institution. (Will appear in full in *Proc. U. S. Nat. Museum,* v. 25, pp. 505–507.)

The genus *Mancasellus* was established by Harger from the form *brachyurus.* There are, up to the present time, but four known species; *M. brachyurus* Harger, *M. macrourus* Garman, *M. lineatus* (Say) and *M. tenax* Harger, and one subspecies *M. tenax dilata* Harger. The genus is not represented outside of North America. This paper contains a description of *Mancasellus danielsi,* which comes from Lily Lake, Indiana, and was collected by Mr. L. E. Daniels.

A New Terrestrial Isopod of the Genus Pseudarmadillo, from Cuba: Harriet Richardson, Smithsonian Institution. (Will appear in full in *Proc. U. S. Nat. Museum,* v. 25, pp. 509–511.)

The type and only species of the genus *Pseudarmadillo, P. carinulatus,* was described by Saussure. The new species, *P. gittianus,* described in this paper was collected by Messrs. Palmer and Riley at Neuva Verona, Isla de Pinos, Cuba. The description is from a single specimen.

The Axial Skeleton of the Enteropneusta, Considered from a Functional Point of View: WILLIAM EMERSON RITTER, University of California. (Will appear in full in 'Scientific Results, Harriman Alaska Expedition.')

(1) The notochord is not restricted to the pouch-like organ present in the adults of all species and hitherto regarded as constituting the entire organ, but in reality extends back to the posterior end of the collar (fully developed in the adult of the Harrimaniidæ and rudimentary in other species). The collar notochord is mainly in the form of a broad, deep trough on the dorsal side of the esophagus, though histologically and functionally portions of the esophageal wall adjacent to the trough must be reckoned as belonging to the notochord. (2) The combined notochord and chondroid skeletal elements constitute a structural unit, this unit being a true *axial skeleton.* (3) This axial skeleton has a twofold function; (*a*) to serve as a firm rod for giving rigidity and strength to the peduncle of the animal, and to support, at its anterior end, the heart and glomerulus which are situated in the base of the proboscis; (*b*) to serve as the origin of the great radio-longitudinal muscles of the collar. (4) The important muscles above mentioned are attached to the sides of the axial skeleton along its entire length from the mid-peduncle to near the posterior end of the collar. They have an extensive insertion into the connective tissue of the collar, the septum between the collar and abdominal cœlom, and the collar ectoderm. These muscles are practically the only ones in the collar by which the boring and locomotor movements of the animal are effected there being in this region no body-wall muscles at all in some of the species. They are consequently true *skeletal muscles* acting on an *internal skeleton,* and *hence having no counterpart in any invertebrate,* but are comparable with the *axial skeletal musculature* of *vertebrates.* The functional significance of the axial skeleton as above defined has not been recognized heretofore, probably on account of the rudimentary condition of its esophageal portion in most species. In particular, its relation to the skeletal musculature has escaped adequate recognition. In the facts here briefly set forth we have evidence *as strong as that furnished by the branchial apparatus* in favor of the chordate affinities of the enteropneusta.

Evolution and Distribution of the Mastodons and Elephants in North America: HENRY FAIRFIELD OSBORN, Columbia University. (Will appear in full in *American Naturalist.*)

CH. WARDELL STILES,
Secretary.

SCIENTIFIC BOOKS.

The Elements of Insect Anatomy, an outline for the use of students in entomological laboratories. By JOHN HENRY COMSTOCK and VERNON L. KELLOGG. Third edition, revised. Ithaca, N. Y., Comstock Publishing Co. 1901.

Teachers of entomology will certainly welcome this revised edition of an excellent laboratory guide. In their selection of easily accessible types the authors have had in mind the convenience of instructors and classes throughout the country. The outlines are carefully constructed with a view to insuring accuracy of observation and include, perhaps, as much material as can be worked over during the time usually allotted to the subject in our colleges and universities. The work suffers somewhat from lack of symmetry. Thus before introducing the student to the maze of sclerites and other anatomical details, with which the outlines begin, it would have been desirable to insert a chapter on general morphology for the purpose of elucidating the important principles of metamerism, cephalization, etc. This could have been accomplished by constructing a number of brief comparative outlines of several insects repre-

senting the different natural orders, together with outlines of a few common myriopods and arachnids. The cockroach, in the opinion of many teachers, would furnish a more satisfactory paradigm of insect structure than the grasshopper. At any rate, the work would gain by including a full outline of both insects. The chapter on the mouth-parts should have been extended to include outlines of the alimentary tracts of several different insects and of some one holometabolic insect in its different instars. Good dissections of the alimentary tract are easily made by the beginner and are eminently instructive both anatomically and physiologically. The same is true of the reproductive organs of insects. While these additions would considerably increase the size of the book, they would also increase the opportunities for selection on the part of the teacher and student. *"Wer Vieles bringt, wird Manchem Etwas bringen"* is as true of insect anatomy as of any other extensive subject.

The chapter on the structure and venation of wings is excellent, as would be expected from the authors' valuable researches on these organs. This and the chapter on the mouth-parts are the only portions of the book in which the principles of comparison, which redeem the sterility of anatomical details, are really accentuated. The former chapter is also the only one that is at all adequately illustrated with clear, simple figures. The concluding chapter on histological methods is also excellent and will be useful to the student in other fields of animal morphology. One notes with pleasure that there are still investigators bold enough to prefer the cumbersome but accurate sliding microtomes to the unreliable rotatory machines of our laboratories. The authors have unfortunately omitted more than a mere reference to the celloidin method, which deserves much more attention in insect histology than it has received.

The outlines exhibit few inaccuracies in detail, and perhaps none as flagrant as those which characterize the table of correspondences between the male and female reproductive organs on p. 46. The seminal vesicles do not correspond, morphologically at least, to the egg calyces, and it is quite erroneous to describe the ejaculatory duct as 'the united vasa deferentia' and the vagina as 'the united oviducts.' The penis, moreover, is neither analogous nor homologous to the ovipositor, and it is difficult to see why these organs should be made to correspond to each other.

It is greatly to be regretted that the clear and straightforward English of the authors should be marred in this, as in the previous editions, by a belated propaganda for an anatomical nomenclature as inelegant as it is unnecessary. The increasing reluctance of American zoologists to use terms like 'proximad,' 'distad,' 'mesad,' etc., is significant and should have been heeded by the authors. The instructor is certainly to be commended who compels his students to translate all these university provincialisms into normal English before beginning to use the otherwise admirable outlines.

The typography, paper and especially the binding are all that can be desired in a laboratory guide.

W. M. Wheeler.

Neudrucke von Schriften und Karten über Meteorologie und Erdmagnetismus herausgegeben von Professor Dr. G. Hellmann. No. 14. *Meteorologische Optik.* Berlin, A. Asher and Co. 1902. 4to. Pp. xiv + 107.

This, the latest and probably the last of the reprints of rare meteorological and magnetic memoirs to be published by Dr. Hellmann, treats of a subject that has not been considered before in the series and, since optical phenomena were among the earliest to be observed, the present memoirs extend over the long period from 1000 to 1836. The special subjects comprise first, four important memoirs on the rainbow, namely, by Theodoricus Teutonicus (1311), Descartes (1637), Newton (1704) and Airy (1836); two descriptions of the Brocken spectre and the white fog-bow by Ulloa and Bouguer (1744–48); three papers on halos, namely, descriptions of remarkable phenomena of this kind seen by Hevelius in Danzig (1672) and by Lowitz in St. Petersburg (1794), besides the fundamental essay of Fraunhofer (1825) on the formation of colored

coronæ. There follow a memoir on mirages by Monge (1797) and an account by Scoresby (1820) of some remarkable atmospheric reflections and refractions in the Greenland Sea; the earliest discussion of twilight by Alhazen (about 1000) and the first good account of the anti-twilight arch by Mairan (1753). The volume contains several illustrations, which like some of the text are in facsimile, and is enriched with the usual historical and explanatory notes. Dr. Hellmann's work is always so exact that it is a surprise to find slight typographical errors on page 83 in the reprint of Scoresby's paper. Like its predecessors, the present volume is published with the aid of the German Meteorological Society, which has fixed the price at 11 marks ($2.75), and although it is not on sale in this country, two or three copies may be purchased at the above price from the Blue Hill Observatory, Hyde Park, Mass. Before closing my reviews of these reprints of rare papers, it should be mentioned that already several of the preceding thirteen numbers are out of print, which shows that Dr. Hellmann's enterprise has been quickly appreciated by librarians and private collectors of historic documents.

A. LAWRENCE ROTCH.

SCIENTIFIC JOURNALS AND ARTICLES.

Bird Lore for July–August opens with an entertaining article 'Concerning the Bad Repute of Whiskey John' by Fannie Hardy Eckstorm, and this is followed by some well illustrated 'Nighthawk Notes' by George H. Selleck. Ernest Crosby contributes a poem on 'The Veery's Note' and John Hutchins describes in some detail 'The Nesting of the Yellow-Throated Vireo.' Edith M. Thomas commemorates in verse the destructiveness of 'The Sapsucker,' and the instalment of 'How to Name the Birds' is devoted to the vireos, warblers and pipits. The reviews and reports of societies are of interest, as is also the editorial on nomenclature.

The Plant World for July contains 'Through Desert and Mountain in Southern California' by S. B. Parish, 'The Protection of Native Plants' by Idelette Carpenter and 'Plants used for Cuban Confectionery' by Charles Louis Pollard. In the supplement devoted to the Families of Flowering Plants Mr. Pollard continues the descriptions of the families of the Polemoniales.

The Museums Journal of Great Britain begins its second year with the July number. The Report of the Council of the Museums Association states that the publication of the *Journal* has been in every way a success and that it will soon begin the publication of a Directory of Museums as a Supplement. The first instalment will probably be in the August number. The leading article is the address of the president of the Museums Association, Mr. W. E. B. Priestly. There is a description of a museum microscope which has just been placed on the market by Messrs. W. Watson and Sons. As now arranged this instrument is limited to 12 slides, but we see no reason why it could not be so modified as to take slides placed on an endless belt after the method devised by Dr. J. M. Flint and used in the Army Medical Museum. There is a too brief account of the opening of the very interesting War and Peace Museum at Lucerne, designed to illustrate the history and horrors of warfare with a view to aiding in its abolishment.

The American Naturalist for August contains a description, in some detail, of 'The Anatomy of a Double Calf' by H. L. Osborn, an account of 'The Metamorphosis of *Sisyra*' by Maude H. Anthony, which contains as well many details of the anatomy of the larva and of wing variation in the adult. Henrietta F. Thacher describes 'The Regeneration of the Pharynx in *Planaria maculata*,' and William A. Hilton 'A Structural Feature connected with the Mating of *Diemyctylus viridescens*,' these being the small pits on the sides of the neck. These are much larger in the male than in the female and their secretion is thought to attract the female and cause her to follow the male after mating. C. R. Eastman gives 'Some Hitherto Unpublished Observations of Orestes St. John on Palæozoic Fishes' and S. N. Rhoads presents some observations on 'The

Marsh or Rice Field Mice of the Eastern United States.' The number contains the 'Quarterly List of Gifts, Appointments, Retirements and Deaths.'

DISCUSSION AND CORRESPONDENCE.

SCIENTIFIC NOMENCLATURE.

To the Editor of Science: In Science for March 21, 1902, Mr. Frank W. Very writes an article on 'Scientific Nomenclature'; he says that "Scientific descriptions remain unintelligible to the lazy man who hates to use the dictionary. They are free property to all who are willing to take this trouble." Mr. Horace White comments on this in the number for March 28, and gives the word 'ecology' as one which he could not find; the discussion which followed has been interesting and instructive; Dr. George M. Gould, the learned editor of *American Medicine*, gave it an editorial notice in his journal of July 19. I fully indorse Mr. Very's opinion of the 'lazy man,' but one who hunts up all words that are new to him will have many disappointments if he expects to find them all; during the past month I have been keeping a list of words not in the dictionaries that I have; these dictionaries are Webster's International, edition of 1890; the Universal or Encyclopedic, 1897, edited by Robert Hunter and Charles Morris; and the Century, edition of 1902. Following is the list of words, with the name of the user, and place where I found them:

Chemotactic, S. J. Meltzer, M.D., *American Medicine*, Vol. IV., p. 61.

Isotonic (in a chemical or physiological sense), do., p. 63.

Epeirogenic, Robert T. Hill, *National Geographic Magazine*, July, 1902, pp. 228, 238.

Electron (in reference to an atom of electricity), J. A. Fleming, *Popular Science Monthly*, May, 1902, p. 6.

Micromil, do., p. 10.

Avalent, do., p. 15.

Sterochemistry, do., p. 15.

Catalyzer, Carl H. Eigenmann, *Popular Science Monthly*, May, 1902, p. 39.

Sedentation, Professor W. H. Holmes, 'National Museum Report,' 1900, p. 177.

Automatograph, Geo. M. Stratton, Science, July 4, 1902, p. 25; Milieu, Geo. M. Stratton, Science, July 4, 1902, p. 25. (A French word, but one meets it occasionally.)

Tropism, Professor E. B. Titchener, *Popular Science Monthly*, March, 1902, p. 463. (Also in Science, XV., pp. 793.)

Chemoreflex, do., p. 463.

Photo-reception, do., p. 465.

Pylophore, Professor J. C. Branner, *Popular Science Monthly*, March, 1902, p. 407.

Garial, Professor S. W. Williston, *Popular Science Monthly*, February, 1902, p. 314.

Acutiplantar, Robert Ridgway, 'Birds of North and Middle America,' Part I., p. 24.

Esthetology, J. W. Powell, 'Report of the Bureau of American Ethnology,' 18, Part I., p. xxvi.

Sophiology, J. W. Powell, 'Report of the Smithsonian Institution,' 1898, p. 45.

Activital, J. W. Powell, 'Report of the Bureau of American Ethnology,' 18, p. xxvi.

Conventionize, -ism, do., pp. xxx, xxxi.

Demonomy, J. W. Powell, 'Report of the Bureau of American Ethnology,' 15, p. xix. (In sense of 'science of humanity.')

Accultural, -ed, do., 18, pp. xxxiv, xxxvii.

Protolithic, do., 18, pp. xxxvii, xxxviii.

Technolithic, do., 18, p. xxxviii.

Lexic, do., 18, p. xlii.

Peyote (mescal), do., 18, pp. xxviii, xliv. (Also Havelock Ellis, *Popular Science Monthly*, May, 1902, p. 52.)

Prototroch, Robert Payne Bigelow, 'Reference Handbook of the Medical Sciences,' 1902, Vol. IV., p. 656.

Biophor, do., p. 654.

Bionomics, Charles Sedgwick Minot, Science, July 4, 1902, p. 5.

Ethology (biologic meaning), William Morton Wheeler, Science, Vol. XV., p. 975.

Orthogenesis, H. Spencer (quoted from Eimer), 'Principles of Biology,' Vol. I., p. 563.

Determinant (in Weismann's sense), H. Spencer, 'Facts and Comments,' p. 129.

These have been noted during the past month; many of them are self-explanatory; a few are found in the dictionaries, but with no meaning given to correspond with that which the user wishes to convey; there are no doubt good reasons why these are not given in the dictionaries, but it seems to me that some of them deserve a place therein.

R. H. Harper.

SHORTER ARTICLES.

MAN IN KANSAS DURING THE IOWAN STAGE OF THE GLACIAL PERIOD.

Two miles southeast of Lansing, Kansas, and about twenty miles northwest of Kansas City, a human skeleton was found last spring by farmers in digging a long tunnel excavation for use as a dairy cellar. Soon after the discovery, the place was visited by M. C. Long and Edwin Butts, of Kansas City, the former being curator of the public museum there, for which they obtained the skeleton. Mr. Butts, a civil engineer, made measurements of the excavation, which extends 72 feet into the bluff. Its floor is a nearly level stratum of Carboniferous limestone; and its lower part consists of débris of limestone and earth, while its upper part is the fine calcareous silt called loess. The skeleton was found mostly in a disjointed and partly broken and decayed condition, at the distance of 68 to 70 feet from the entrance of the tunnel, about two feet above its floor, and 20 feet below the surface of the ground exactly above it. Half of the lower jaw was found ten feet nearer the entrance, and a foot lower, than the principal parts of the skeleton, including the other half of the lower jaw.

About a month ago this locality was carefully examined again by Mr. Long and Professor S. W. Williston, of the Kansas State University, and the latter wrote a short article, 'A Fossil Man in Kansas,' which was published in SCIENCE, August 1. Before this article appeared, newspaper accounts had been seen by Professor N. H. Winchell, of Minneapolis, and by myself in St. Paul, which had led us to plan a journey to Kansas, partly for the purpose of examining the Lansing skeleton and the drift section in which it was discovered. We accordingly visited this tunnel excavation, at the house of Martin Concannon, on Saturday, August 9. Professors S. W. Williston and Erasmus Haworth, of the State University, Lawrence, Kansas, and M. C. Long, Sidney J. Hare, and P. A. Sutermeister, of Kansas City, accompanied us. Mr. Concannon, owner of the farm, and his sons, who dug the tunnel and found the skeleton, were also present and explained again all the circumstances of their discovery.

The entire section of the tunnel, which is about 10 feet wide, 7 feet high with arched top, and 72 feet long, was examined; additional bones, as of the hands and feet, were found in the dump outside; and the skeleton, in Kansas City, was inspected. According to Professor Williston's measurements of the bones, the fossil man was about five feet eight inches in stature, and was probably more than fifty years of age, as estimated from the worn condition of the teeth. The skull is dolichocephalic, with receding forehead, strongly developed supraciliary ridges, and a markedly prognathous face and chin. Most of the vertebræ and ribs are wanting, probably because of their decay previous to the deep inhumation by the overlying loess.

The skeleton lay in the upper part of the earthy débris, including many limestone fragments of small size and some as large as two or three feet in length. Just above it, at an irregular line a few inches to a foot higher, a horizontally stratified water deposit of fine loess begins, forms the upper two thirds of the tunnel, and extends up to the surface 20 feet above the place of the skeleton. The loess continues up to Mr. Concannon's house, which is about 100 feet distant, on a slight terrace, about 35 feet above the horizon of the skeleton, and 47 feet above the level reached by the adjoining Missouri river at its highest flood since Mr. Concannon's settlement here 35 years ago. This flood, in 1881, was 25 feet above the lowest stage of the river, which is 735 feet above the sea. The Carboniferous limestone outcrops about 50 feet southeast of the house, and rises gradually in a spur ridge southeastward to a height of 150 feet or more above the river.

Within a quarter of a mile southward, and also within a half mile to the west and northwest, the loess forms uplands about 200 feet above the Missouri; and at the end of the loess deposition it doubtless stretched as a broad floodplain, 200 or 250 feet above the present river level, across the Missouri valley, which has been subsequently re-excavated. The skeleton appeared to all our party to have

been entombed at the beginning of the loess deposition, which would refer it to the Iowan stage of the Glacial period, long after the ice-sheet had receded from Missouri and Kansas, but while it still enveloped northern Iowa and nearly all of Wisconsin and Minnesota. In other words, it belonged to a time before the prominent moraines of these last-named states were formed on the borders of the waning ice-sheet. The very old Kansas glacial drift, including many boulders of the red Sioux quartzite, is very thinly spread on this northeastern part of Kansas, under the loess, and reaches about 30 miles south of Lansing, terminating along an east to west boundary 12 to 15 miles south of the Kansas or Kaw River.

The loess and the Lansing skeleton are of Late Glacial age, but are probably twice or perhaps three times as ancient as the traces of man in his stone implements and quartz chips occurring in glacial gravel and sand beds at Trenton, N. J., and Little Falls, Minn. In the Somme Valley and other parts of France, as also in southern England, stone implements in river drift prove that man existed there before the Ice age, that is probably 100,000 years ago, or doubtless four or five times longer ago than the date of the skeleton at Lansing, Kansas.

Warren Upham.

NOTES ON INORGANIC CHEMISTRY.

It appears from a recent paper in the *Berichte* that Dr. Marckwald has at last succeeded in preparing a specimen of polonium, the radio-active element associated with bismuth, in such a way that the question of its being a peculiar form of bismuth itself may be set aside. The method used was to take a specimen of strongly radio-active oxychlorid of bismuth, dissolve it in acid, and then precipitate the metal by a rod of pure metallic bismuth. Under these circumstances the bismuth becomes coated with a black deposit, which seems to be nearly pure polonium, inasmuch as the radio-activity of the solution is wholly concentrated in the black deposit, which is itself extremely active. The amount obtained from several kilos of pitchblende residues was only a few milligrams, from which it was estimated that the amount of polonium in pitchblende is not over one gram per ton. Dr. Marckwald hopes, however, to obtain enough of the pure metal by this method to determine its atomic weight.

K. A. Hofmann has also continued his work on radio-active substances from the uranium minerals, especially upon radio-active lead. The radium so obtained is very much more active upon the photographic plate than is polonium. A specimen of radio-active lead sulfid, which acted powerfully upon a photographic plate, was much weaker in discharging the electroscope than a specimen of polonium oxychlorid, which had no effect whatever through a thin gutta percha film upon a photographic plate, even after twenty hours' exposure. He found that radio-active lead preparations gain in activity by preservation in a dry condition in closed tubes. A number of metals seem capable of robbing uranium of its activity. In one experiment a solution of pure uranium was mixed with barium and the latter precipitated by sulfuric acid. The uranium thereby lost completely its activity both toward the electroscope and toward the photographic plate; after standing two days in a closed tube the uranium regained its activity. The same phenomenon was observed in another experiment when bismuth was substituted for barium. A number of the rare earths, such as thorium, erbium, didymium, cerium and lanthanum, are capable of receiving an induced activity from uranium, and the same is true, not only of barium, but also of strontium and calcium. Activity is very slightly induced in yttrium and not at all in glucinum and zirconium. Lead receives a weak activity when precipitated from the uranium solution with sulfuric acid, but none at all when the precipitant is caustic potash.

The same number of the *Berichte* contains a paper by Stock and Doht continuing their investigations of stibin, SbH_3. This hydrid of antimony was obtained in the solid state some years ago by Olszewski, but great difficulty had been experienced by him and by them in obtaining more than a very small trace of the gas from the materials used. The

method used by the authors consists in decomposing alloys of antimony with dilute acids, but in their experiments with the ordinarily used zinc-antimony alloy, the hydrogen evolved contains under the most favorable conditions, less than one per cent. of stibin. After experimenting with several alloys, that of antimony with magnesium proved to be by far the best. With such an alloy containing thirty-three per cent. of antimony, the gas given off on treatment with cold dilute hydrochloric acid contains upwards of fourteen per cent. of stibin, and nearly three fourths of the antimony used is obtained as the hydrid. This is readily condensed by liquid air to a colorless solid, melting to a colorless liquid at —88° and boiling without decomposition at —17°. When the gas is perfectly pure it is fairly stable, but after some hours it begins to decompose with the deposition of metallic antimony. It decomposes rapidly at 150°.

Analyses of two specimens of early Egyptian remains have been recently published. The first is a vase of the fourth dynasty, and from the analysis Berthelot concludes that it was originally produced by baking a mixture of fine sand with litharge and common salt. The other specimen was a cold chisel dating from the Thébaines dynasty. This consisted of two parts cemented together, the outer portion being of an alloy containing 92.6 per cent. copper and 4.7 per cent. tin. The core was much richer in tin, having 84.6 per cent. copper and 13.3 per cent. tin.

J. L. H.

SCIENTIFIC NOTES AND NEWS.

DR. ALEXANDER AGASSIZ has been appointed a member of the Prussian order, 'pour le merite.'

THE committee of the fund raised to commemorate the eightieth birthday of Professor Virchow announces that it has handed over a sum of over $12,000 to the Rudolf Virchow Foundation.

DR. CH. WARDELL STILES, zoologist of the Bureau of Animal Industry, U. S. Department of Agriculture since 1891, has been transferred to the U. S. Treasury Department as 'chief of the Zoological Division, Public Health and Marine-Hospital Service of the United States,' with permanent headquarters at the Hygienic Laboratory in Washington, D. C. The Zoological Division is a new division recently authorized by congress for the purpose of investigating the practical relations of zoology to public health matters. It is made a part of the Hygienic Laboratory authorized by congress several years ago.

THE advisory committee appointed by King Edward in connection with the erection of a sanatorium for tuberculosis in England announces that 180 essays were sent in in competition for the three prizes. The first prize, of the value of £500, has been awarded to Dr. Arthur Latham.

THE Society of Arts has awarded the Shaw prize for industrial hygiene to Mr. James Tonge, Jr., of Westhoughton, Lancashire, for his hydraulic mining cartridge.

NESTOR PONCE DE LEON, M.D. (Columbia), has been appointed medical inspector for the port of Havana.

THE introductory address of the Medical Department of Owens College, Manchester, will be given by Sir Dyce Duckworth on October 1.

DR. GEORGE REISNER has returned from Egypt, where he has been making archeological collections for the Phoebe Hearst Museum in the University of California.

DR. W. F. HENDRICKSON, instructor in pathology in the University of Pennsylvania, died on August 21, at the age of twenty-six years.

MR. GEORGE M. HOPKINS, the author of works popularizing science and one of the editors of the *Scientific American*, died on August 17, at the age of sixty years.

DR. EMILE DUNANT, curator of the Archeological Museum at Geneva, was killed on August 22 while ascending Mount Pleureur.

THE death is announced of Dr. Leopold Schenk, formerly professor of embryology at the University of Vienna. It will be remembered that Dr. Schenk published a work on the

determination of sex which did not meet the approval of scientific men. It was claimed that it was used for advertising purposes, and he was retired from his chair at the University at the request of the faculty.

The Civil Service Commission announces an examination on September 15 to fill positions of physiological chemist and chief of the drug laboratory in the Bureau of Chemistry of the Department of Agriculture. The salary of these positions is $2,000. Applicants need not appear at any place for examination, the entire weight being laid on education, training, experience and scientific papers. On October 4 there will be held an examination for the position of chemist in the road-material laboratory of the Bureau of Chemistry at the same salary. Two examinations for positions in the Philippine service are also announced on September 30, one for the position of expert in animal industry with a salary of $2,500, and one for the position of instrument maker in the government laboratory with a salary of $1,200.

It is stated in *Nature* that Gilbert White's house at Selbourne is again for sale, and the suggestion is made by Mr. E. A. Martin, member of the council of the Selbourne Society, that it should be purchased as a permanent memorial of the father of British naturalists. The house, known as The Wakes, is situated in the main street of the village of Selbourne, and is in much the same condition as is was in White's time. The question of the existence of a portrait of Gilbert White is discussed by Hr. R. Holt-White in a letter to the August number of *Nature Notes,* with the result that there is no good reason to believe that any such picture is known.

Reuter's Agency reports that the Prince of Monaco has presented a quantity of deep-sea apparatus to Mr. W. S. Bruce for the Scottish Antarctic Expedition, including trawls, nets, water-bottles for obtaining samples of water from great depths for physical examination, thermometers and other similar apparatus.

We learn from the *British Medical Journal* that the Pasteur Institute of Warsaw, founded 15 years ago, has during that period performed some 500,000 antirabic inoculations. Recently an accident occurred of which there had been no previous example. Of 40 persons inoculated on November 29th, 1901, 22 were attacked with illness. Of these 6 were children, 4 of whom died with symptoms resembling those of scarlatina. The other persons presented only local manifestations. The Institute was closed and disinfected, and the performance of inoculation was not resumed till December 20th, when fresh spinal cords procured from St. Petersburg and Cracow were employed. Dr. Palmciski, the director of the institute, is investigating the cause of the outbreak, which is believed to be due to secondary infection, and on completion of the inquiry the results will be made public.

We learn from the *Botanical Gazette* that in connection with the Royal Botanical Gardens at Peradeniya an experiment station has recently been established for trying on a large scale new products not yet staples. The purchased estate contains 550 acres.

At a meeting held at the Apothecaries' Hall, says the *British Medical Journal,* it was resolved to call the new society for investigating drugs and their uses the 'Therapeutical Society,' and to include treatment by natural forces and by surgical appliances as well as by drugs in the subjects to be discussed.

An International Congress on the care of the insane is to be held at Antwerp this year from September 1 to 7. The Belgian Minister of Justice is the honorary president of the congress, and the acting-president is Dr. Peters, of Gheel.

The newspapers report that news has been received of the Nordenskjöld Antarctic expedition. The vessel is imprisoned in the ice, according to these advices, and preparations have begun to proceed in dog sledges. The health of the members of the party was excellent.

News has been received at Yokohama that the small island of Tori Shima, between the Bonin Islands and Hondo, the main island of Japan, was overwhelmed by a volcanic eruption between the 13th and 15th of the month.

All the houses have been demolished and the 150 inhabitants killed.

THE Berlin correspondent of the *Times* says that the scientific commission sent by the German Sea Fisheries League to ascertain the value of deep sea fishing in the Baltic has not yet published its report. It is known, however, that large fishing grounds were not found and that trawl fishing as practiced in the North Sea would not pay.

AN industrial exhibition is being planned for Johannesburg, South Africa. It will embrace mining and agricultural machinery, motive powers, tramways and various industries. The arts and sciences will be included in the scope of the exhibition.

THE *Botanical Gazette* states that the serial publication known as 'Contributions to the U. S. National Herbarium' was transferred from the Department of Agriculture to the National Museum with a special appropriation of $7,000. This provides for an editorial assistant and an artist, and will enable the museum to republish certain numbers which are out of print and in demand.

FROM a letter dated Kechatno River, June 28, from Mr. A. H. Brooks, geologist in charge of the Alaskan work of the Geological Survey, the latest information is received regarding the progress of exploration in that territory. Mr. Brooks is at present leading an exploring party which started late in May from near the head of Cook Inlet, on the southern coast, to explore the unknown region of the western Alaska Range and to reach Circle City, on the Upper Yukon, before the arrival of cold weather. The distance is about 600 miles, 100 of which had been traversed at the date of the letter. The route taken from Cook Inlet was northward, partly along the beach and partly by Indian trail parallel to the shore of the inlet. Beluga River, a formidable stream over which it was necessary to swim the horses by means of boats, was successfully crossed. Thence northwestward a well-forested foothill region with abundance of grass was traversed to the Skwentna River, which was crossed with difficulty owing to its low temperature and rapid current. A portion of the outfit was then sent by boat to the Kechatno River, while the rest of the party went overland to meet it through a region of extensive swamps where it was necessary to cut the trail for almost 30 miles. From Kechatno River the route lies across the Alaska Range, partly by the trail used by Captain Herron in 1899, thence to the Tanana River and northeastward to Circle City. If the season is found to be too far advanced on reaching the Tanana, the river will be descended to the Yukon, and passage will be taken on one of the boats going down the latter river. In spite of the difficulties of travel experienced to this point, the party is reported to be in excellent health and spirits. The topographer of the expedition is Mr. D. L. Reaburn, and the assistant geologist is Mr. L. M. Prindle, who has already made a valuable collection of plants.

WE learn from *Nature* that the text of the draft scheme of organized research on cancer, adopted by the Royal College of Physicians on March 24 and approved by the Royal College of Surgeons on April 10, has now been published. The scheme states that in order to promote investigations into all matters connected with, or bearing on, the causes, prevention and treatment of cancer and malignant disease, steps are to be taken, (1) to provide, extend, equip and maintain laboratories to be devoted exclusively to cancer research; (2) to encourage researches on the subject of cancer within the United Kingdom or in the British dominions beyond the seas; (3) to assist in the development of cancer-research departments in various hospitals and institutions approved by the executive committee; (4) and generally to provide means for systematic investigation in various other directions into the causes, prevention and treatment of cancer. Should the object of the fund be attained by the discovery of the cause and nature of cancer, and of an effective method of treatment, the Royal Colleges, with the consent of the trustees, are to be empowered to utilize the fund either (*a*) for equipping with the necessities for such treatment such hospitals as they may select, or (*b*) for forwarding research into other diseases. The fund is to be administered by a president, vice-presidents, trustees, honorary treasurer,

general committee, and executive committee consisting of twelve members, one to be nominated by the Royal Society.

Bulletin No. 35, entitled 'Eucalypts Cultivated in the United States,' by Professor A. J. McClatchie, agriculturist and horticulturist of the Arizona Experiment Station, will be ready for distribution by August 15, 1902. Forty species of Australian Eucalypts, which have been successfully grown in the southwestern part of the United States for timber, for windbreaks or for ornament, are fully described and illustrated in this bulletin. The little-known distinguishing characteristics of the seedling and older growth of these trees have received special attention and illustration; as have their requirements for soil, climate and culture. The phenomenally rapid growth of the Eucalypts renders them of very great economic importance in suitable climates; and tree planters and others who desire information concerning the character, culture and economic uses of these trees and their wood will find in this bulletin a useful guide.

The *Electrical World* describes the progress toward establishing a John Fritz medal. As we have already stated, representative members of the four national engineering societies have organized for the purpose of celebrating suitably the eightieth birthday of John Fritz, the celebrated American ironmaster and inventor. Under discussion the plan developed until it was decided to establish a John Fritz medal, to be awarded every year 'to the originators of the most useful scientific or industrial achievements, in perpetual honor of John Fritz and to the glory of engineering.' In order that the subscribers to the fund should be numerous, it was decided to permit each one to contribute $10. Enough has now been subscribed to insure the success of the project, but there is still an opportunity for those who wish to be enrolled. Several thousand dollars have been received. The purpose is that this medal shall be awarded by a perpetual committee of 16, to be appointed or chosen in equal numbers from the American Society of Civil Engineers, the American Institute of Mining Engineers, the American Society of Mechanical Engineers and the American Institute of Electrical Engineers. Rules for the award of this medal have been prepared. The committee may select any person of any nationality. No award shall be made until after at least one year of consideration, and it must have the affirmative vote of at least three fourths of the board. The hope and belief is that this medal will be a distinction not second to the Bessemer gold medal, awarded by the Iron and Steel Institute of Great Britain. The public celebration of Mr. Fritz's eightieth birthday and of the foundation of this memorial will be held in New York City, October 31. This celebration will take the form of a dinner at the Waldorf-Astoria, in which the subscribers to the fund will have the first opportunity to participate. Those who may wish to be enrolled among the subscribers to the medal fund should write for particulars to Mr. John Thomson, treasurer, 253 Broadway, New York City.

UNIVERSITY AND EDUCATIONAL NEWS.

President Pritchett, of the Massachusetts Institute of Technology, has declined the presidency of the University of Wisconsin.

The trustees of the University of Chicago have again postponed the decision as to the segregation of the sexes at the University. It is said that a majority of them do not favor the plan recommended by President Harper.

Dr. J. H. Beal, a chemist, has been elected president of Scio College, at Scio, Ohio.

William Stuart, B.S. (Vermont, '94), M.Sc. (Purdue, '96), associate horticulturist of the Indiana Experiment Station, has resigned to accept the professorship of horticulture in the University of Vermont.

The Council of University College, Liverpool, has elected Dr. Benjamin Moore, now lecturer in physiology in the Charing Cross Medical School, to the chair of bio-chemistry, recently founded in the college by Mr. William Johnston.

Professor Hans Strahl, director of the Anatomical Laboratory at Giessen, has been called to Tübingen.